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Study of Gamma Burst of 1 August 1983 by 'Prognoz-9' Artificial Earth Satellite

18660187a Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 4, Apr 88 (manuscript received 21 Sep 87) pp 323-326

[Article by M. I. Kudryavtsev and S. I. Svertilov, Moscow State University]

[Abstract] The 'Prognoz-9' artificial earth satellite was used in carrying out an experiment for the study of gamma bursts. Among the 15 bursts registered the strongest was that of 1 August 1983. Registry was with a scintillation spectrometer effective in the photon energy range 10-200 KeV with an effective area of about 40 cm2. The x-ray instrument axis coincided with the axis of satellite rotation, which during the flight was oriented on the sun each 5-7 days. Virtually continuous measurements of x-ray fluxes were made in the energy intervals 10-50, 25-50, 50-100 and 100-200 KeV. The telemetric system operated in two main modes; a constantly operative mode ensured measurement of the mean counting rates of x-ray photons in 10 seconds. When particularly strong x-ray fluxes were observed the telemetric system ensured measurement of the counting rate with a time resolution of about 1 second, as in the case of the event of 1 August 1983. In addition to strong radiation in the energy range above 50 KeV with a rather hard spectrum, this burst was characterized by the presence of a soft component which is traced in the region of medium-energy x-radiation 10-50 KeV. Prior to this only a few gamma bursts had been observed in which x-radiation had been observed. In these events the x-radiation spectrum became softer as the bursts developed (this is interpreted as the gradual cooling of these regions). Figure 1; references 5: 3 Russian, 2 Western.

UDC: 523.64

Chaotic Dynamics of Halley's Comet

18660187b Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 4, Apr 88 (manuscript received 2 Feb 87, after revision 9 Jul 87) pp 357-363

[Article by V. V. Vecheslavov and B. V. Chirikov, Nuclear Physics Institute, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] The clearly expressed irregularly changing period of Halley's comet suggests dynamic chaos, although the historical record of 45 revolutions is too short for a reliable statistical analysis. Accordingly the authors have formulated a simple model of cometary motion which embodies the most important characteristics of its long-term dynamics and makes it possible to extend numerical modeling and analytical estimates up to the total time of cometary presence in the solar system. The model is used in demonstrating that the motion of Halley's comet is chaotic. Some of its statistical characteristics are given. Estimates of the errors and the limit of numerical extrapolation of the chaotic trajectory are given. The dynamic limitations on the total time of cometary presence in the solar system, which in large part are dependent on small nongravitational forces, are examined. The nature and significance of these nongravitational forces are discussed and quantitatively evaluated. For example, precession of cometary perihelion results in the periodic intersection of its orbit with the Jovian orbit which could result in the direct ejection of the comet from the solar system with a very close approach to Jupiter, although this could not occur for a very long time in the future. Some of these factors are compensated by others. In order of magnitude the time of presence of Halley's comet in the solar system (about 107 years) is consistent with the age of hypothetical cometary showers from the Oort cloud. Figures 3; references 12 Russian; 7 Russian, 5 Western.

UDC: 523.4

Determining Trajectory of Balloon Motion in Venusian Atmosphere by Very Long-Base Interferometry Method

18660187c Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 4, Apr 88 (manuscript received 25 Dec 87) pp 364-370

[Article by R. Z. Sagdeyev, L. I. Matveyenko, R. Preston, L. R. Kogan, K. Hildebrand, V.I. Kostenko, I. A. Strukov, I. G. Moiseyev, R. L. Sorochenko, R. M. Martirosyan, Ye. P. Molotov and M. V. Golovnya, Space Research Institute, USSR Academy of Sciences, Moscow; Radio Physics and Electronics Institute, Armenian Academy of Sciences; Main Astronomical Observatory, Ukrainian Academy of Sciences, Goloseyevo; Crimean Astrophysical Observatory, USSR Academy of Sciences, Nauchnyy; Jet Propulsion Laboratory, United States; Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] As part of the "Vega" project two balloon probes were released into the Venusian atmosphere from flyby vehicles in June 1985. These balloons carried transmitters operating in the 18-cm wavelength range. The method of differential radio interferometry with a very long base (VLBI) was used for ensuring the necessary accuracy in measuring coordinates (30 km) and velocity (1 m/s). Almost all the major radio telescopes in the world participated in this program, but this article is largely confined to an analysis of data collected using the Ussuriysk-Yevpatoriya base. After discussing determination of the model of motion of these balloons on the basis of Doppler frequency measurements using one telescope, the determination of the mean trajectory of balloon motion from interference frequency measurements is illustrated. It is shown that in the southern Venusian hemisphere the "Vega-2" balloon moved at a mean velocity of 66 m/s; the latitudinal component of velocity was 3.4 plus or minus 0.5 m/s and was directed to the north. The "Vega-1" balloon velocity in the northern hemisphere was 69 m/s and was directed virtually parallel to the equator. In certain cases there were

changes in signal frequency corresponding to oscillation of the suspended instrument package with a period of about 7.4 seconds. Figures 4; references: 8 Russian.

UDC: 523.4

Jovian Model With Different Chemical Composition of Molecular and Metallic Envelopes

18660187d Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 4, Apr 88 (manuscript received 30 Jul 87, after revision 14 Dec 87) pp 371-378

[Article by T. V. Gudkova, V. N. Zharkov and V. V. Leontyev, Earth Physics Institute imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow]

[Abstract] New models of the internal structure of Jupiter which conform to recent observational data on the Jovian gravity field and atmospheric composition are outlined. The proposed models have different chemical composition of the molecular and metallic envelopes. The molecular envelope is formed of an ice component, whereas the metallic envelope consists of ice and/or heavy components. The following models were examined: with an identical composition of the molecular and metallic envelopes on the basis of the so-called M1 adiabat; with an identical chemical composition of the molecular and metallic envelopes on the basis of the so-called M2 adiabat; with different chemical composition of the molecular and metallic envelopes on the basis of the M1 adiabat; with different chemical composition of the molecular and metallic envelopes on the basis of the M2 adiabat. These four models were computed on the assumption of solid-body rotation. Two types of models were constructed: with a homogeneous composition of the envelopes with respect to helium and with the full composition of hydrogen and helium for the planet close to that of the sun. Calculations indicated that the ice plus heavy component in Jupiter is about 10 times more abundant than in primordial matter. The selected model is compared with other research in which the possibility of molecular and metallic envelopes with different chemical composition was not considered. Despite many uncertainties, in the computed model the mass of the Jovian core is consistent with the critical mass of the nucleus at which gas collapse occurred. Figures 5; references 22: 7 Russian; 15 Western.

UDC: 629

Length of Measurement Sessions With Weak Influence of White Noise

18660189a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 5 May 87) pp 179-183

[Article by M. L. Lidov]

[Abstract] A study is made of the problem of estimating motion parameters when measurement errors consist of the sum of a random process with unknown correlation function plus white noise. The asymptote of the optimal estimate is obtained assuming weak influence of white noise. References 2: Russian.

UDC: 521.182

Single-Step Methods For Predicting Orbital Motion Considering Its Periodic Components

18660189b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 20 Mar 86) pp 184-192

[Article by K. N. Lavrov]

[Abstract] Modern numerical methods for integration of ordinary differential equations can provide accurate and universal solutions to celestial mechanics problems. The implicit single-sequence algorithms of Everhart and multiple-step computational schemes using a priori information on periodic components can be combined to construct implicit single-sequence algorithms which combine their advantages. This article studies the construction and analysis of the properties of such algorithms, utilizing trigonometric approximation of the solutions of differential equations containing periodic components. The algorithms require 10 percent more machine memory than the Everhart algorithms, but are twice as fast, and yield short-term predictions valid for five to ten orbits with good accuracy and five to six times faster than algorithms using other methods. Figures 2, references 5: 2 Russian, 3 Western.

UDC: 629.7

Evolution of Rotation of Gyrostat Satellite Carrying Viscous-Elastic Discs in Circular Orbit

18660189c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 17 May 87) pp 193-198

[Article by B. G. Demin, V. Ya. Konks and Yu. G. Markov]

[Abstract] A study is made of the motion of a symmetrical gyrostat satellite around its center of mass when a viscoelastic homogeneous disc-ring is located in the equatorial plane of the satellite's ellipsoid of inertia. The rotor is assumed to be statically and dynamically balanced. The center of mass of the system is assumed to move in a circular orbit in a newtonian force field. Approximate equations are produced which describe the evolution of the rotary motion of the system. The steady motion of the system is determined and its stability is estimated. The solution assumes rotation of the system around its axis of symmetry, which coincides with a perpendicular to the orbit. References 5: Russian.

UDC: 629.7.1.30.82

Motion of Tether During Deployment and Retrieval of Tether System in Orbit
18660189d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 4 Mar 86) pp 199-208

[Article by Ye. M. Levin]

[Abstract] Some processes involved in deployment and retrieval of a weightless tether have been studied. Considering the weight of the tether greatly complicates the problem. This article presents a new form of the equation of motion, facilitating both analytic and numerical investigation of this case. The study is performed for two satellites connected by a tether of variable length in elliptical orbit, with the tether assumed to be very flexible but not elastic. The excitation of transverse oscillations of the tether as it is deployed or retrieved is studied. It is shown that as the tether is smoothly deployed, a quasisteady bending shape develops, while retrieval characteristically produces transverse oscillations. Figures 3, references 11: 7 Russian, 4 Western.

UDC: 533.6

Approximate Analytic Method of Calculating Spatial Maneuvers of Spacecraft in Atmosphere
18660189e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 7 Apr 86) pp 209-219

[Article by N. L. Sokolov]

[Abstract] An approximate analytic method is suggested for computing the three-dimensional maneuvers of a spacecraft in the atmosphere. A comparative analysis of results obtained by numerical integration of the equation system describing the motion of the spacecraft, both using an exponential model of the atmosphere and using approximate analytic equations, shows a variation of four to five percent with a reduction in machine time of 20-25 times. The error of computation is estimated for spacecraft with zero and with constant values of lift to drag, and also for optimal control problems. Figures 3, references 24: 14 Russian, 10 Western.

UDC: 533.6

Two Types of Nonlinear Resonant Motion of Asymmetrical Spacecraft in Atmosphere
18660189f Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 27 Jan 86) pp 220-226

[Article by V. S. Aslanov]

[Abstract] Previous studies have presented a linear analysis of resonant oscillations of an asymmetrical spacecraft in the atmosphere resulting from manufacturing inaccuracy, slight asymmetry of shape and loss of heat-protective coatings. This article presents a nonlinear statement of the problem as the spacecraft descends through the atmosphere. Two possible types of resonant motion are computed: roll and rotational resonance. Averaged equations are presented and necessary and sufficient conditions are found for the existence of stable resonance. Equations are obtained for critical asymmetry parameters resulting in resonant oscillations. Figures 3, references 7: Russian.

UDC: 629.197.23

Minumum-Pulse Spacecraft Stabilization
18660189g Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 6 Dec 85) pp 227-235

[Article by L. D. Akulenko]

[Abstract] A study is made of a model of the control rotation of an asymmetrical solid relative to its center of mass in the form of the Euler equations for an absolutely solid body. Stabilization is achieved by firing a motor rigidly attached to the spacecraft. Stabilization can be achieved with two impulses, the magnitudes and moments of which are computed. The impulse approximation of control pulses is quite convenient for reaction engines. In the degenerate case of a spherically symmetrical spacecraft, three fixed pairs of impulses, not in the same plane, may be required. Figures 2, references 14: 12 Russian, 2 Western

UDC: 629.7

Three-Dimensional Motion of Deformable Body in Central Force Field
18660189a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 2 Nov 87) pp 236-246

[Article by Yu. G. Markov]

[Abstract] Evolutionary equations for three-dimensional translational-rotary motion of a deformable body with dissipation of energy in a central newtonian force field are produced in canonical variables. The equations can be used to trace the evolution of motion of the center of mass of a sphere and the kinetic moment vector relative to the center of mass, describing the effects of the tidal theory of motion of the planets in particular. The process of evolution of the translational-rotating motion of a viscoelastic sphere is described, in which the vector of kinetic moment relative to the center of mass approaches a direction orthogonal to the plane of the orbit during the process of evolution, with the plane of the orbit becoming orthogonal to the vector of the moment of momentum of the body relative to the attracting center. The orbit of the center of mass of the sphere become circular, while the sphere itself becomes nonmoving in the orbital system of coordinates. References 8: Russian.

UDC: 537.12+550.388.2

Saturation of Turbulent Energy Density in Longitudinal Currents

18660189i Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 27 Mar 86) pp 247-255

[Article by S. L. Shalimov and V. A. Luperovskiy]

[Abstract] Electrostatic turbulence level saturation is studied as a longitudinal current flows through a magnetosphere as a function of current density, demonstrating that saturation is satisfactorily explained by the concept of excitation of electrostatic ion-cyclotron and ion-sonic turbulence on auroral force lines. If the ion-cyclotron instability is stabilized by spreading of ion resonances, the turbulence varies with longitudinal current according to the limitation of turbulent energy density as the current increases. More intensive longitudinal currents excite instability, causing unsteady turbulence which decreases with time. The maximum level of turbulence is independent of longitudinal current. Figures 2, references 22: 11 Russian, 11 Western.

UDC: 550.388

Satellite and Surface Measurement of Latitudinal Distribution of Upper Ionosphere Parameters Near Main Ionospheric Trough

18660189j Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 15 May 86) pp 256-262

[Article by V. M. Filippov, V. N. Alekseyev and V. V. Afonin]

[Abstract] Results are presented from coordinated measurements performed on 26-27 March 1979, when the "Intercosmos-19" satellite measured incoming electron parameters, the "Cosmos-900" measured the concentration and temperature of electrons, and surface geophysical methods were used to record the luminance of the 630.0 nm line and the convection parameters of the plasma in the F area were measured, along with the position of the polar edge of the main ionization trough. These combined measurements allowed detailed comparison of successive positions of the boundary of diffuse electron precipitation and the position of the polar edge of the main ionospheric trough, as well as changes in the plasma drift picture. The measurements proved the reliability and suitability of the method of reciprocal oblique ionospheric soundings for determination of the position of the polar edge of the trough, allowing the method to be used to diagnose the large-scale structure of the ionosphere at high latitudes. Figures 3, references 17: 12 Russian, 5 Western.

UDC: 581.521

Specifics of Motion of High-Energy Protons In Terrestrial Radiation Belts

18660189k Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 19 Mar 86) pp 263-269

[Article by I. V. Amirkhanov, Ye. P. Zhidkov, A. N. Ilina and V. D. Ilin]

[Abstract] Numerical integration of the equation of motion of particles in a dipole magnetic field is used to study: nonlinear oscillations between reflection points of protons with impulse between $2/L^2$ and $15/L^2$ GeV, the position of the cone of losses as a function of system parameters, and the reason for accumulation of albedo protons. The accumulation of albedo protons results from losses of particle motion stability. The mixing of phases and pitch angles due to stochastic instability results in quasicapture and temporary retention of protons. As the adiabatic parameter increases, the loss cone is transformed from a straight line to a closed curve, at which point normal-shaped particle sinks are formed in the magnetosphere. The albedo proton flow intensity within ovals between 23 and 48 and 90 and 160° may average an order of magnitude less than outside these angle ranges, which must be considered in differential particle flux measurements. Figures 5, references 12: 10 Russian, 2 Western.

UDC: 533.95:551.510.535

Dynamics of Electron Beam Injected Into Ionosphere Near Satellite

18660189l Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 16 Sep 85) pp 270-278

[Article by V. A. Fedorov]

[Abstract] A study is made of the dynamics of an electron beam in the vicinity of a satellite when the beam is influenced by the electric field of the charged satellite. The study shows that the influence of the electric field of the satellite and of the ionospheric plasma must be considered. The variable component of the satellite's electric field modulates the beam at the plasma frequency and causes a fast spatial period to appear in its structure. The static component of the satellite's electric field influences both the geometric characteristics of the beam and the dynamics of the electrons in the z plane. The effect of the ionospheric plasma on electron beam dynamics is to define the characteristic dimensions and frequency of the beam. References 20: 16 Russian, 4 Western.

UDC: 523.72

Interplanetary Plasma Density Fluctuation Spectrum Based on "Prognoz-8" Satellite Measurements

18660189m Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 9 Apr 86) pp 289-297

[Article by I. V. Chashey, T. D. Shishova and L. A. Avanov]

[Abstract] This article is dedicated to investigation and interpretation of the solar wind ion fluctuation spectrum at 2 times 10^{-3}—10 Hz on the basis of measurements performed by the "Prognoz-8" satellite in an orbit with an apogee of 200,000 km in January of 1981. The fluctuations measured indicate that the spectrum of fluctuations of the interplanetary plasma density is piecewise-exponential with exponent 1.55 at frequencies of less than 0.6 Hz and 2.0-3 at frequencies of over 0.6 Hz. This indicates a significant level of turbulent pulsations related to density fluctuation. The pulsations can be interpreted as magnetosonic waves propagating at a great angle to the magnetic field. There is a break in the turbulence spectrum corresponding to a scale of about 10^7 cm in the terrestrial orbit. Figures 2, references 21: 10 Russian, 11 Western.

UDC: 523.035:525.72

Spectrometry of Weak, Rapidly Varying Sources In X-Ray and Gamma Astronomy

18660189n Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 14 Jul 87) pp 298-305

[Article by M. S. Burgin and A. S. Smirnov]

[Abstract] Many x-ray and gamma radiation source observations are performed with multichannel low-resolution spectrometers. Parameter fitting is usually performed by the chi-square minimum method. With variable sources, the total number of photons recorded from a source is limited, and the spectrum of the source may vary during the period of accumulation. This makes the problem of selecting the optimal observation time difficult. This article suggests several methods for solving the problem, and presents an investigation of the behavior of spectral parameter estimates with small numbers of recorded photons. Statistical modeling is used to investigate methods for selecting accumulation times to minimize error. The results indicate that restoration of spectra from observations with less than a critical number of recorded photons should be avoided. Physical conclusions can be made only on the basis of a large number of individual model parameter determinations. If an individual observation does not provide the required accuracy, a procedure of restoring the spectrum based on data produced by adding a number of measurements should be used, rather than averaging the individual results of restoration. Figures 3, references 10: 5 Russian, 5 Western.

UDC: 629.7

Gravitational Orientation of Artificial Satellites With Gyrodynes

18660189o Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 17 Nov 86) pp 315-317

[Article by V. V. Sazonov]

[Abstract] Damping devices are required to provide gravitational orientation of satellites with destabilizing aerodynamic forces. Gyroscopic damping can be successfully used with at least one two-stage gyroscope, although systems with two such gyroscopes are more common. A system of gyrodynes can be used for gyroscopic damping by determining the required gyrodyne control rule. This article studies two simple model rules for control of the kinetic moment of a system of gyrodynes providing asymptotic stability of triaxial gravitational satellite orientation in order to demonstrate the possibility in principle of utilizing this method of damping. References 7: 6 Russian, 1 Western.

UDC: 539.165

High-Energy Electrons In Outer Terrestrial Radiation Belt

18660189p Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 13 Oct 86) pp 322-324

[Article by S. A. Averin, A. M. Galper, V. M. Grachev, V. V. Dmitrenko, V. D. Maslov and S. Ye. Ulin]

[Abstract] High-energy electrons (with E over 20 MeV) were first recorded in the inner radiation belt by the "Yelena-F" instrument on the "Salyut-6"—"Soyuz"—"Progress" orbital complex. Experiments on the "Salyut-6" and "Intercosmos" satellites have determined the pitch-angle distribution of electrons and positrons in the belt. Studies continue on the "Salyut-7" and "Meteor-3" satellites. This article presents the results of investigation of high-energy electrons (E at least 30 MeV) in the outer radiation belt by the "Intercosmos-Bulgaria-1300" satellite in circular orbit at 900 km altitude, inclination 81° using a gas Cerenkov telescope and scintilation counters with lead absorbers. The fluxes of captured electrons are found to exceed the mean level of quasicaptured electrons, with an intensity maximum in the shells L=3.2-3.4. The presence of high-energy electrons at this level and the nonuniformity of their population indicate once more that the formation of particles with high energies is related to their acceleration and diffusion in the magnetosphere. Figure 1, references 14: Russian.

UDC: 523.72

Structure of Interplanetary Fluxes Based on Plasma and Magnetic Field Measurements By "Prognoz-6" Satellite on 25-26 November 1977
18660189q Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 6 May 86) pp 324-328

[Article by Ye. G. Yeroshenko, K. G. Ivanov, M. I. Verigin, G. A. Kotova, and V. A. Styazhkin]

[Abstract] Two fluxes from a flare and a coronal hole on 25-26 November 1977 were observed aboard the "Prognoz-6" satellite. This article presents a comparative analysis of the magnetic and plasma data based on these observations and observations of other Soviet and American spacecraft which were located at that time near a line between the Sun and the Earth. The "Prognoz-6" data recorded disturbances in the magnetic field and plasma near the Earth during passage of the isolated flare flux and the quasisteady flux from the coronal hole. A perpendicular to the head of the shock wave of the flare flux was found to be at Φ_n 126°, and θ_n -17°. The magnetic cloud from the flare was measured over a period of 19 hours as an area of relatively strong field, sparse plasma, β less than one, with near regular variations of all B components. The normal and inner structure of the magnetic cloud magnetopause were measured. More than 10 intersections with the leading edge of the magnetospheric shock wave were recorded while the geomagnetosphere was within the magnetic cloud, indicating an increase in the cross section of the transient area as the magnetosphere and cloud interacted. The normal to the leading shock wave of the flux from the coronal hole was at Φ_n 248°, θ_n -30°. The boundary of the quasisteady flux was identified and had almost the same changes in plasma and magnetic field parameters as the flare flux boundary. Figures 3, references 9: 3 Russian, 6 Western.

UDC: 550.510.535

Packet of Medium-Scale Wave Fluctuations of Nocturnal Middle-Latitude Outer Ionosphere Electron Concentration Based on "Intercosmos-10" Data
18660189r Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 23 Jun 86) pp 329-330

[Article by S. K. Annakuliyev, K-U. Vagner, and M. N. Fatkullin]

[Abstract] An attempt is made to trace changes in a narrow packet of medium-scale wave disturbances in the outer nocturnal ionosphere at middle latitudes with latitude based on measurements made by the "Intercosmos-10" satellite. Heterogeneities had a characteristic size of a few hundred kilometers. The intensity of the heterogeneities was found to decrease with increasing latitude. Figures 2, references 7: 6 Russian, 1 Western.

UDC: 550.383

Cosmic Rays In Near-Earth Space In 1977-1979 Based on "Cosmos-900" Data
18660189s Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 7 Jul 86) pp 331-334

[Article by Ye. V. Gorchakov, V. G. Afanasyev, K. G. Afanasyev, V.A. Iozenas, P. P. Ignatev and M. V. Ternovskaya]

[Abstract] A study is made of the readings of channels I, III, V and XI of a Cerenkov counter with 18 energy recording thresholds and a time resolution of about 20 seconds carried on the "Cosmos-900" satellite at an altitude of 460-550 km, orbital inclination 83°. The variation in radiation outside the radiation belts with latitude is illustrated. There is a maximum in additional radiation with a sharp cutoff for vertically arriving particles at 0.7-2 GV. A split is observed in the periequatorial radiation. The flux in channel XI is approximately double the flux of galactic α particles in the middle latitudes. The approximate doubling in the counting rate in channel XI in comparison to the expected α-particle count is not yet explained. Figures 2, references 11: 5 Russian, 6 Western.

UDC: 523.4-52

Evolution of Dust Condensations in Preplanetary Disk
18660193a Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 1, Jan-Feb 88 (manuscript received 4 Apr 86) pp 58-72

[Article by G. V. Pechernikova and A. V. Vityazev, Institute of Terrestrial Physics imeni O. Yu. Shmidt, USSR Academy of Sciences]

[Abstract] Dust condensations formed after the dust subsided in the circumsolar preplanetary disk and after development of gravitational instability in the dust subdisk. A theoretical discussion is presented of the evolution of these condensations within the framework of models of the formation and evolution of the circumsolar dust-and-gas disk and the formation of the planets in it. The mechanisms facilitating the effective compression of condensations at the earliest stages of their evolution are discussed briefly. The precollision and collision evolution of condensations are discussed, as well as the growth of the largest condensations. The relationship between the dimensions, mass, density and spin of condensations is studied and an estimate is made of the time it took them to grow and be transformed into solid bodies. Processes are discussed for the system on average and it is emphasized that fluctuations play an

important role by virtue of the very nature of the random process of collision. The mass of a condensation is doubled as the result of the collision of condensations comparable in dimensions and mass. The effective compression of condensations accompanied by their growth is facilitated by the presence of a scattered dust component in the system. Although it is too early to draw final conclusions, it appears reasonable that the transformation of condensations into solid bodies in the region of the planets of the Earth took place over the course of 100,000 to one million years. The largest bodies could attain a radius of 1000 km. A cluster of bodies having a wide range of masses formed by the final stage of condensation. The condensation stage could last longer and effective compaction could occur with much greater masses in the region of the outer planets. The variation in the specific spin of bodies in the process of their interaction should be taken into account in models describing the evolution of the preplanetary disk from the formation of condensations to the formation of planets and the idea of unique congruence between the mass and radius of bodies should be rejected. Figures 3; tables 2; references 10: 8 Russian, 2 Western.

UDC: 523-1/-52

Features of Drop Model of Protoplanetary Disk

18660193b Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 1, Jan-Feb 88 (manuscript received 31 Jan 86) pp 73-85

[Article by Ye. M. Levin, Institute of Machine Science, USSR Academy of Sciences]

Abstract] The drop model of a protoplanetary disk postulates a cluster of spherical bodies moving in a single plane in circular orbits around an attracting center, whereby the bodies are united during collision. The evolution of this model is discussed within the framework of the coalescence theory, based on the ideas and results of T. M. Eneyev and N. N. Kozlov (1977, 1980). Eneyev and Kozlov discovered density waves in studying the evolution of the drop model of a protoplanetary disk. A numerical study made by them of a model containing tens of thousands of bodies demonstrated the pattern of the formation of alternating annular regions of higher and lower density in the initially uniform disk. A single planet ultimately forms in each region of higher density. The radii of the boundaries of these regions form on average a geometrical progression consistent with the positioning of the planets in the solar system. Eneyev and Kozlov suggested an approach from the viewpoint of the coalescence theory for studying the evolution of the drop model with a very large number of bodies. The coalescence equation is derived and an analytical solution is given. It is demonstrated that the drop model permits a complete analytical study within the framework of the coalescence theory. The following dynamic features of the disk's evolution are revealed: The origin of annular standing density waves representing forms of the development of the instability of a differentially rotating disk of accumulating bodies. The arrangement in a geometrical progression of the boundaries of the regions of higher and lower density. A close relationship between the radial redistribution of mass and the buildup of the angular momentum of the bodies' proper rotation. The predominance of direct proper rotation. A ⅔ relationship between the bodies' specific angular momentum and their mass, which results in rotation isochronism. Figures 3; references 15: 9 Russian, 6 Western.

UDC: 523.985

Directional Effect of Hard X-Radiation of Solar Flares As Detected by SNEG-2MZ Instruments

18660193c Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 1, Jan-Feb 88 (manuscript received 30 Jan 86) pp 147-156

[Article by S. V. Bogovalov, Yu. D. Kotov, V. M. Zenchenko, G. Vedrenne, N. Niel, K. Barat, G. Chambon and P. Talon, Moscow Engineering Physics Institute; Institute of Space Research, USSR Academy of Sciences; Cosmic Radiation Research Center, Toulouse, France]

[Abstract] About 300 solar flares were recorded from November 1981 through January 1983 in the course of the Soviet-French SNEG-2MZ experiment on board the Venera-13 and Venera-14 spacecraft, during which information was obtained on the hard x-radiation of solar flares. The SNEG-2MZ instruments registered x-radiation continuously with 2-minute resolution in five energy channels in the 50 to 800 keV range. Here the results are presented of a statistical analysis of the relationship between the radiation spectrum indicator and the angle of observation of flares registered by these instruments in the 50 to 360 keV range. Systematic softening of the x-radiation spectra of flares toward the center of the solar disk was observed in the photon energy region of 50 keV and higher. The radiation spectra observed experimentally are compared with spectra calculated within the framework of a model of a "thick" target, taking into account the Coulomb scattering of electrons and the albedo of radiation from the photosphere. In a considerable percentage of the flares the angular distribution of electrons accelerated above an energy of 50 keV is anisotropic. The comparison presented makes it possible to conclude that the softening of spectra observed toward the center of the solar disk is most likely due to the angular anisotropy of accelerated electrons. More statistics on flares are needed in order to make a final decision regarding the extent of this anisotropy and it is necessary to know the angular distribution of the intensity of the x-radiation generated by the electron beam when the electrons strike the sun's surface at random. The angular distribution of electrons must be taken into account in reconstructing the spectra of electrons in the source of the generation of x-radiation. The results obtained indicate that the angular distribution of electrons varies for each flare. Figures 6; table 1; references 26: 12Russian, 14 Western.

Phobos Mission Plan, Scientific Goals

18660179a Moscow KRASNAYA ZVEZDA in Russian 23 Apr 88 p 4

[Article by Colonel M. Rebrov: "Project 'Phobos' or a Journey into the Past, the Present and the Future"; first two paragraphs are source introduction]

[Text] **In the time machine thought up by the fantasy writers, it is possible to take an unusual journey: to return to the remote past, to approach at a certain "distance" the moment of the solar system's birth or to dash far ahead and "see" the universe as it will be in the future. Fantastic, is it not? And enticing also! But reality, at times, is more surprising than any fiction and, therefore, "movement through time" becomes even more exciting when it is not associated with fantasy. The realization of Project Phobos will make possible a real journey into the past and speculations about the future.**

No one has yet favored the Sun's large family, with its giant planets and quite diminutive celestial bodies, with such attention—two flying laboratories, outfitted by Soviet scientists together with colleagues from many countries of the world and the European Space Agency, are being prepared to be launched to the plain "little chunk," quite small according to the scale of the universe, which is revolving around the enigmatic planet Mars.

Thus, Mars and Phobos. The supreme, endless and boundless universe and its "inhabitants" harbor many riddles for science. People are sending their own hand-made automatic observation craft in the hope of solving them. Among them is the Phobos spacecraft.

First, regarding the stages of the flight and the route's terminal point. A Proton launch vehicle will first place the automatic laboratory, concealed under the nose cone, into a satellite orbit around the Earth. Thence, from this "intermediate cosmodrome", the station will follow a course towards Mars.

The voyage's duration is 200 days. At the moment of arrival—this has been calculated with adequate accuracy—the distance from the Earth to the Red Planet amounts to 190 million kilometers, while the path which must be traversed on Earth-Mars route is much greater: nearly 500 million km.

Upon approaching the planet, the craft will enter into an elongated elliptical orbit above the Martian equator. The automatic observation craft's camera eyes will see Mars' surface from a distance ranging from several hundred kilometers to several tens of thousands of kilometers.

The craft will operate in this orbit for 60 days (or a little bit less), after which, upon commands from Earth, it will transfer to a circular orbit with an 8-hour period of revolution. The earthlings' envoy will be in this orbit from 35 to 140 days, gradually closing with Phobos. After a specified amount of time, the orbit will become synchronous with the pericenter (the point of an orbit which is closest to the central body) of 9,400 km. It is precisely along this orbit that the very enigmatic Phobos revolves.

What then? The spacecraft will approach its surface and, from a distance of several tens of meters, on a "grazing" flight, the planned research will be conducted. Using low-thrust engines, the earthlings' envoy will almost hover above Phobos' surface.

But even this is still not everything. The project makes provision for a landing by a long-lived (that is what the scientists call it) station, which will continue research right at the "contact" site. The entire mission is intended to last 460 days.

The very same route and maneuvers will be used by the second craft, an exact duplicate of the first, which will be launched from Baykonur several days later.

Now, about the scientific program. It is comprehensive and lasts a protracted amount of time. In January of 1989 the scientists will begin to receive television pictures of Mars, in which details several kilometers in size will be visible. The instruments installed on board both automatic laboratories will make it possible to gather data in order to form a subsequent opinion about the chemical and mineral composition of the rocks and their radiophysical characteristics. Computer processing of the information will make it possible to compile a thermal map.

Landing on a planet or its satellite and beginning research there without violating the sterile conditions is impossible. The very presence of an "alien" craft and the operation of its braking engines, naturally, will leave "traces." Therefore, it is necessary to conduct analysis from a distance during the drifting process above the Martian moon. In order to do this, a special laser cannon was developed. Glowing for an instant, the bright laser burst will reach Phobos' surface and, in an area of one square millimeter over the course of a minuscule fraction of a second (one one-hundred millionth), will develop 100 megawatts of power.

The laser beam, in evaporating Phobos' material, will create a "cloud" of ions—the smallest charged particles. A special "vacuum cleaner-trap" will draw them into a very special chamber, where the particles' spectrum will be determined. The on-board computers will send these data to Earth, where the scientists will be able to draw a conclusion about the composition of Phobos' material. In other words, we will find out about a material which has been preserved untouched since those times long ago when the planets were only just forming.

The infrared spectrometers will study the surface's thermophysical and reflective properties, the diurnal and seasonal dynamics of its temperature conditions and will

seek out sections of internal heat emanation and permafrost regions. Sensitive instruments will assist in determining the basic rock-forming radioactive elements existing there. The images and spectrograms will make it possible to go one step farther—the compilation of a surface map of the unusual Martian satellite.

Yet another "cannon"—a plasma one—will irradiate a 100-square meter area of the surface with a stream of krypton ions. The secondary particles ejected from Phobos' soil will be analyzed by a special mass analyzer, which will yield a key to the understanding of the numerous processes of the past.

The television cameras will take photos simultaneously in three spectral bands. This will make it possible later to synthesize color photos from the black-and-white photos.

Also part of the program for the future scientific work is the study of the Martian atmosphere: the recording of changes in the spectrum of solar radiation during its passage through the planet's atmosphere. This, supposedly, will make it possible to obtain an answer to the question: are ozone, water vapors, oxygen molecules and dust present there? And the observation of the Sun will yield interesting and important information about cosmic gamma-ray bursts.

Also natural is the question: why is Phobos so interesting to science? This insignificant satellite of such an esteemed planet?

To put it bluntly, there is very little information in Phobos' "file": it is 27 km long, with a mass that is 1.5 times 10^{-8} the mass of Mars and a density of 2 g/cm^3. That, essentially, is everything.

And yet, there has been a lot of speculation about this enigmatic body. Particularly curious is the fact that the existence of the two Martian moons was predicted by the writer, Jonathan Swift, in "Gulliver's Travels." Half a century passed before the astronomer, A. Hall, in 1877, discovered Mars' satellites, which received the names Phobos and Deimos (Greek for "fear" and "terror"). And, although the first space observation craft to Mars was sent by Soviet scientists and designers in 1962, after which six more of our automatic stations went to the Red Planet and the American Mariner and Viking craft visited those "regions," even today the trajectory of the Martian moons' movement is still puzzling to scientists.

At one time, speculation was expressed (or more accurately—a rather well-reasoned hypothesis) according to which Phobos was not a product of nature, but rather, an artificially made object. But then another question arises: by whom?

More recent research has shown that both satellites—shapeless lumps—have crater markings, "streaked" by a large number of furrows (and this also requires an explanation). Astronomers agree that these bodies are not hollow (such an opinion also existed), rather they are massive lumps of the asteroid type and original objects of the solar system. If this is so, then the successful completion of the Phobos project will also clear up many secrets which give science no rest.

Man—a citizen of the Universe—has been trying for a long time to understand the great wonder of nature, when, from the initial "point" of an unknown force, the "Big Bang" spewed out that which we call today planets, suns, stars and galaxies... And, indeed, the knowledge of history is also a prevision of the future.

In any case, after many (but not all!) scientists chose to lay to rest the matter of any kind of life on Mars (there are proponents of the hypothesis that the likeliest form of life are lichens. They can survive where the sole source of water is atmospheric vapor), interest was not lost in other problems: "Why did the water disappear from Mars? What is the history of its magnetic field? How can knowledge about it supplement the pages of our Earth's history?"

The projects, the plans, the accomplishments... Only the most precise equipment, reliable, responsive and sensible, can solve such complex problems. And the greatest difficulty here is how, within the weight and size limitations, to "cram in" as many instruments, devices and systems as possible.

"The Phobos spacecraft," said V. Kovtunenko, corresponding member of the USSR Academy of Sciences, "is the first example of a new generation of Soviet scientific spacecraft capable of solving problems of this type. The latest advances in Soviet space equipment have been concentrated in it..."

Yes, a lot of pains have been taken with the "Phoboses." They have been equipped with electronic "brains" capable of solving problems of an adequately high "intellectual level," unique sensitive instruments, trajectory change equipment, actuators, navigational systems and, of course, units for analysis and processing of the collected information.

Thus, the launches take place on 7 and 12 July. We will wait. "And hurry also," joke astronomers. They reckon that, according to the cosmic time scale, if it is figured that the birth of the universe occurred 10-15 billion years ago, humanity has "only" 30-70 million years left for the study of Phobos. At the end of this time, it will fall to Mars' surface. Oh well, we will hurry.

And there is one more idea: a manned flight to Mars. Fantasy or reality? The impractical dream of hasty people or a flight put off until later? Arguments are going on now about this. Heated, impassioned. Participating in them are scientists, designers and simply adherents of space travel. They argue about the design features of a Martian "starship," about the most advantageous flight

paths and about the timing for a possible launch. The opinions are as varied as can be. The versions are numerous. But they all agree on one thing: if there is a manned fligh' then the most important link in the complex project is Man.

Today the automatic devices are breaking the trail for man.

UDC: 621.317:523.43

Paleomagnetism of Mars
18660190 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 2, Mar-Apr 88 (manuscript received 28 Oct 87) pp 306-314

[Article by Sh. Sh. Dolginov]

[Abstract] The planet Mars has a very weak magnetic field. Several suggestions have been made to explain this fact: it is related to residual magnetization of martian rock by a previous dynamo field in the liquid conducting core of the planet; it results from a present dynamo process generating a very weak field; the magnetic field of Mars is in the phase of inversion. Models of the internal structure of Mars based on numerous measurements of a wide variety of physical factors indicate that Mars has gone through a stage of differentiation and does have a liquid, melted core. The physical similarity of the field of Mars and the fields of the other planets is another important argument indicating that the field observed is being generated by a present-day dynamo process. The suggestion that Mars previously had a more intensive dynamo field follows directly from equations which have been derived to describe the martian field, considering the probable more intensive precession of the planet in the distant path under the influence of the gravitational fields of more massive satellites which previously orbited Mars and have since disappeared based on the specific shapes of craters near the equator, the deficit of angular momentum of the present system of Mars plus Phobos and Deimos, the periodic changes in the inclination of the axis of rotation of Mars to its orbital plane, and the martian origin of the SNC meteorites. The presumed intensive dynamo field of the past should be "recorded" in martian crustal rock. Future studies of this rock would have a tremendous significance for research on the ancient magnetic field of Mars, as well as its paleoclimate and dynamo theory. References 38: 17 Russian, 21 Western.

UDC: 523.42

Geological-Morphological Description of Lukelong-Okipeta Dorsa Area (Venus Surface Photomap, Sheet B-2)
18660192A Moscow ASTRONOMICHESKIY VESTNIK in Russian No 1, Jan-Mar 88 (manuscript received 28 Oct 87) pp 3-12

[Article by A. L. Sukhanov, A. A. Pronin, N. N. Bobina, G.A. Burba, Yu. S. Tyuflin, M. V. Ostrovskiy, V. I. Kabeshkina, V. A. Kotelnikov, O. N. Rzhiga, Yu. N. Aleksandrov, A. I. Sidorenko, G. M. Petrov, N. V. Rodionova, and O. S. Zaytseva; Institute of Geology, USSR Academy of Sciences; Institute of Geochemistry and Analytic Chemistry imeni V. I. Vernadskiy, USSR Academy of Sciences; Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography imeni F.N. Krasovskiy; Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] Photomap sheet B-2 is one of a series of maps composed as a result of a radar survey of Venus by the Venera-15 and -16 spacecraft. Geological interpretation was performed in 1:4,000,000 scale, the map was generalized to 1:16,000,000 scale. The southern portion of sheet B-2 adjoins sheet B-8, and the geological structures continue from one map to the other. The ridge structures first discovered by Venera-15 and -16 are the dominant structures of sheets B-2, B-8 and B-16, forming a complex system, a fan opening southward, with spaces between belts filled with flatter areas, apparently lava flows. The belts, 20-250 km wide, consist of alternating subparallel ridges and furrows up to 300 km or more in length. Detailed analysis of the images indicates that the belts arose primarily due to stretching and spreading of the lithosphere, forming a series of submeridional cracks which were subsequently filled with magmatic material. The effects of compressive stresses in the formation of the belts cannot be fully excluded but were apparently not very significant. The flat areas show signs of stretching and the rise of magmatic materials as well as differential shear displacement along sublatitudinal fractures. Figures 5, references 3: 1 Russian, 2 Western.

UDC: 523.42

Geological-Morphological Description of Vinmara and Ganiki Planitiae Area (Venus Surface Photomap, Sheet B-8)
18660192b Moscow ASTRONOMICHESKIY VESTNIK in Russian No 1, Jan-Mar 88 (manuscript received 28 Oct 87) pp 13-22

[Article by A. A. Pronin, A. L. Sukhanov, V. P. Shashkina, G. A. Burba, V. A. Kotelnikov, O. N. Rzhiga, Yu. N. Aleksandrov, A. I. Sidorenko, G. M. Petrov, G. A. Krylov, A. A. Krymov, Yu. S. Tyuflin, and M. V. Ostrovskiy; Institute of Geology, USSR Academy of Sciences; Institute of Geochemistry and Analytic Chemistry imeni V. I. Vernadskiy, USSR Academy of Sciences; Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography imeni F. N. Krasovskiy; Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] Sheet B-8 is one of a series of maps based on radar studies of the surface of Venus performed by the Venera-15 and -16 spacecraft. The map presented in this article is a 1:16,000,000 scale map produced by generalization of the original constructed in 1:5,000,000 scale by interpreting radar images. The northern edge of sheet B-8 adjoins sheet B-2, and together they fully cover a unified geological area with development of ridge belts. The major terrain features of the area are meridional belts of ridges with flat areas between them. Other types

of structures include rings, circular or near-circular rims up to hundreds of kilometers across; arachnoids, circular structures with a central complex core and concentric system of ridges; tesserae; and craters. The planes on the sheet show signs of volcanic origin and consist of extensive effusions which occurred under stretching conditions. The ridge belts formed along weaker zones of higher permeability and consist of linear volcanic ridges above tension cracks. The ring structures are spatially associated with the belts and are surface manifestations of hot spots. Later tectonic activity formed a sublatitudinal system of fractures intersecting the planes and ridge belts. Figures 5, references 5: 4 Russian, 1 Western.

UDC: 523.62

Circular Dust Formations Around Earth and Moon and Some Structural Elements of Dust Formation Around Sun

18660192c Moscow ASTRONOMICHESKIY VESTNIK in Russian No 1, Jan-Mar 88 (manuscript received 1 Sep 86) pp 61-70

[Article by V. L. Barsukov and T. N. Nazarova; Institute of Geochemistry and Analytic Chemistry imeni V. I. Vernadskiy, USSR Academy of Sciences]

[Abstract] A reanalysis of data from Soviet and American satellite and rocket experiments of the 1960s and 70s indicates that there are clear patterns in the locations where meteorite impacts are recorded around the Earth: A significant number of such recordings have occurred at the same distances from the Earth, but the time patterns are irregular. This indicates that small meteorite bodies are orbiting the Earth in clusters. These rather dense, large clusters of meteorite bodies, moving in orbits at different speeds, varying with distance from the Earth, explain the "swarms" of meteorites recorded by the GEOS-2 and other satellites. The stable dust formation around the Earth consists of such clusters in orbits with altitudes of 400 to 235,000 km above the surface, with density decreasing with increasing altitude. Similar clusters orbit the Moon, and there are extended dusty formations in orbit around the Sun as well. This article presents the first qualitative description of some of the structural elements of the dust system around the Sun based on measurements by the Venera-2 and Zond-3 spacecraft. Future measurements will generate more detailed information on the orbital dust system around the Sun. Figures 4, references 18: 8 Russian, 10 Western.

UDC: 523.42

Geological-Morphological Description of Loukhy and Atalanta Plains (Venus Surface Photographic Map, Sheet B-7)

18660199a Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 2, Apr-Jun 88 (manuscript received 30 Dec 87) pp 99-111

[Article by A. L. Sukhanov, N. N. Bobina, G. A. Burba, Yu. S. Tyuflin, M. V. Ostrovskiy, V. A. Kotelnikov, O. N. Rzhiga, A. I. Sidorenko, G. M. Petrov, Yu. N. Aleksandrov, V. P. Shubin, V. Ye. Zimov and I. L. Kucheryavenkova; Geology Institute, USSR Academy of Sciences; Institute of Geochemistry and Analytic Chemistry imeni V. I. Vernadskiy; Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography]

[Abstract] Photographic map sheet B-7 is one of a series of maps based on materials of a radar survey conducted by the Venera-15 and Venera-16 spacecraft. Geological interpretation was performed in 1:4,000,000 scale, and the map has been generalized to 1:16,000,000 scale. The banded Loukhy and Atalanta plains, with hypsometric levels plus or minus one km, represent a transition area from the ancient dislocated continental area to the west to the "oceanic" plains with extension bands to the east. They are covered with a network of dikes and fracture zones. They are similar to spreading zones on Earth. The regional spreading in the area could have resulted from two mechanisms: movement of the entire continental mass to the southwest with the formation of the "oceanic" zone between this mass and the eastern Methidus mass; or underthrust of portions of the crust from the east to the west, beneath the crust in the area of Loukhy and Atalanta as a result of spreading with its center to the east. Figures 5, references 3: Russian.

UDC: 523.44

Observation of Asteroid 4 Vesta In Vesta-86 Program

18660199b Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 2, Apr-Jun 88 pp 130-131

[Article by the editors]

[Abstract] In May of 1986, the Astronomical Council of the USSR Academy of Sciences approved a national program of observations of the asteroid 4 Vesta for the opposition of 1986. The major task of the Vesta-86 program was resolution of the uncertainty of the most important characteristics of Vesta. The program yielded a large quantity of observational data, including photometry of the asteroid at 0.92 μm. Analysis of variations in several characteristics of the asteroid showed that the observations correspond to a short period of rotation of Vesta, 5.342 hr, and a surface with great optical property heterogeneity. The experience of the study of Vesta may be useful for the organization of other programs, including those related to the need for ground tracking of space missions to other bodies in the solar system. This issue publishes several articles reflecting the major results of the studies.

UDC: 523.44

Problem of Rotational Period of Asteriod 4 Vesta

18660199c Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 2, Apr-Jun 88 (manuscript received22 Jun 87)pp 131-136

[Article by F. P. Velichko, Astronomical Observatory, Kharkov State University imeni A. M. Gorkiy]

[Abstract] The asteroid Vesta, a large asteroid with a diameter of over 500 km, has an unusual and highly symmetrical brightness curve with neighboring minima

and maxima having almost identical levels of brightness. Even the smallest details of the curve separated by periods of 5.342 hours seem quite similar. It has long been an object of controversy as to whether the 5.342 hour apparent period of the brightness curve represented the true rotational period of Vesta, or whether there were two bright areas and two darker areas on the asteroid, indicating a true period of rotation twice as long. Further studies using various astrophysical methods will be required to determine the true rotational period of Vesta. Figures 3, references 17: Western.

UDC: 523.44

Photometry of Vesta in 1986 Opposition

18660199d Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 2, Apr-Jun 88 (manuscript received 22 Jun 87) pp 136-142

[Article by F. P. Velichko, D. F. Lupishko, V. G. Shevchenko, O. P. Abudadze, L. G. Akhverdyan, R. A. Vardanyan, M. A. Yeritsyan, N. N. Kiselev, L. R. Lisina, L. A. Sigua, and G. P. Chernova; Astronomical Observatory, Kharkov University imeni A. M. Gorkiy; Institute of Astrophysics, Tajik SSR Academy of Sciences; Main Astronomical Observatory, Ukrainian Academy of Sciences; Abastumani Astronomical Observatory]

[Abstract] Photometric observations of Vesta were performed as a part of the "Vesta-86" program at five observatories in August-October 1986 in a photometric system similar to the standard UBV system. All measurements were performed by a differential method using one of two comparison stars during the course of the night. The coordinates and photometric characteristics of the comparison stars are presented in tables. Near the minimum of the brightness curve, the asteroid is also less red (more blue) than at the maximum. The extensive materials of the observation, including brightness and color curves, minimum epochs, absolute values of brightness, phase variation, etc. are required to construct a model of the asteroid describing its shape, period and direction of rotation, orientation of axis of rotation in space, albedo heterogeneities of the surface and other characteristics. Figures 4, references 7: Western.

UDC: 523.44

Polarimetry of Vesta In 1986 Opposition

18660199e Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22, No 2, Apr-Jun 88 (manuscript received 22 Jun 87) pp 142-146

[Article by D .F. Lupishko, I. N. Belskaya, O. I. Kvaratskheliya, N. N. Kiselev, A. V. Morozhenko and N. M. Shakhovskiy; Astronomical Observatory, Kharkov Univerity imeni A. M. Gorkiy; Institute of Astrophysics, Tajik SSR Academy of Sciences; Crimean Astrophysical Observatory, USSR Academy of Sciences; Abastumani Astrophysical Observatory, Georgian SSR Academy of Sciences; Main Astrophysical Observatory, Ukrainian SSR Academy of Sciences]

[Abstract] Polarimetric observations were conducted as a part of the "Vesta-86" program of observation of the asteroid Vesta in its 1986 opposition to produce data on variations in the degree of polarization and brightness of Vesta as it rotated about its axis over at least three successive nights in order to solve the problem of the period of rotation and refine the polarization characteristics of the surface of the asteroid. Within the limits of accuracy of measurement of polarization, it was found to have the same value at moments in time separated by the value of the "shorter" period of 5.342 hours, oreviously suggested as the shortest possible period of rotation of the asteroid. Weather conditions did not permit similar observations to be conducted during several time intervals of at least 5.342 hours in 1986. The minimum of each brightness curve corresponded with the maximum of each polarization curve, indicating probability of the shorter period of revolution. Figures 3, references 10: 4 Russian, 6 Western.

UDC: 523.44

Asteroid 4 Vesta: Photometry In Visual Range and 0.92 m Pyroxene Absorption Band

18660199f Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22, No 2, Apr-Jun 88 (manuscript received 22 Jun 87) pp 147-152

[Article by V. D. Vdovichenko, F. P. Velichko, S. M. Gaysin, S. A. Mosina and S. S. Shumilin; Astrophysics Institute, Kazakh SSR Academy of Sciences; Astronomical Observatory, Kharkov State University imeni A. M. Gorkiy]

[Abstract] The spectrum of the asteroid Vesta has a clear pyroxene absorption band at 0.92 μm. However, almost no observations have been performed to study the changes in intensity and profile of this band. Such observations were performed in September-October 1986. Changes in Δ (v-p) were observed with the phase of rotation of Vesta, probably related to a change in the depth of the pyroxene band, its minimum depth corresponding to the minimum brightness in the visual area. If the variation in depth of the aosorption band is related primarily to the content of pyroxene in the surface layer of the asteroid, then in the area corresponding to the maximum brightness curve the content of this mineral is greater than in the area of minimum brightness. Physical characteristics of the pyroxene, such as particle size, may also influence the Δ (v-p) variation. Figures 3, references 9: 1 Russian, 8 Western.

UDC: 523.44

Surface Polarimetric Heterogeneity of Asteroid 4 Vesta

18660199g Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22, No 2, Apr-Jun 88 (manuscript received 22 Jun 87) pp 152-158

[Article by Yu. G. Shkuratov, Astronomical Observatory, Kharkov State University imeni A. M. Gorkiy]

[Abstract] An attempt is made to explain the variation in absolute value of minimum polarization of the surface of the asteroid Vesta based on model laboratory polarimetric observations. Recommendations are also presented

for further polarimetric studies of the asteroid in order to check and refine the interpretation suggested. The suggested reason for the polarimetric heterogeneity of the surface of the asteroid is changes in such microstructural characteristics as the ratio of quantities and albedo of light and dark surface material fragments in the scale around 1 μm. Figures 4, references 6: 4 Russian, 2 Western.

UDC: 523.44

Laboratory Modeling of Asteroid Brightness Curves

18660199h Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22, No 2, Apr-Jun 88 (manuscript received 22 Jun 87) pp 159-166

[Article by N. I. Koshkin, Astronomical Observatory, Odessa State University]

[Abstract] An analysis is presented of the form of brightness curves generated by several different asteroid models as a function of orientation of the axis of rotation with respect to the observer and the light source. A special photometric installation was used to maintain rather strict physical modeling of the conditions of illumination of asteroid bodies and their visibility conditions from great distances. It was found that the form and amplitude of model brightness curves depend significantly on the properties of the light-scattering surface layer, particularly the albedo with identical scattering diffusion. Models of different shapes with gray surfaces yielded brightness curves differing from a sine wave in various ways, primarily spreading of the maximum and constriction of the minimum. The detailed shape of the brightness curve depended on observation conditions for models of various shapes, manifested as variation in the phase of the harmonics in the expansion of the brightness curves. An ellipsoidal model with a gray coating yielded a brightness curve differing little from a sine wave. Figures 2, references 5: 1 Russian, 4 Western.

UDC: 523.44

Photometry of Amor Asteroids 1036 Ganymede and 1139 Atami

18660199i Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22, No 2, Apr-Jun 88 (manuscript received 22 Jun 87) pp 167-173

[Article by D. F. Lupishko, F. P. Velichko and V. G. Shevchenko; Astronomical Observatory, Kharkov University imeni A.M. Gorkiy]

[Abstract] This article is a continuation of previous works by the same authors on the photometry of Amor-group asteroids and contains more detailed results of the observations of 1036 Ganymede and photometry of 1139 Atami. Photoelectric observations were performed in July-November 1985 (Ganymede) and October, 1986 (Atami) on a 70-cm reflector in a photometric system similar to standard UBV. Figures 5, references 15: 5 Russian, 10 Western.

UDC: 523.44

Spectrometry of Asteroids. IV. Mineral Heterogeneity of Vesta's Surface

18660199j Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22, No 2, Apr-Jun 88 (manuscript received 8 Nov 87) pp 173-182

[Article by L. F. Golubeva and D. I. Shestopalov; Shemakhinskaya Astrophysical Observatory, Azerbayjan SSR Academy of Sciences]

[Abstract] A comparison is presented of the spectra of Vesta obtained during different oppositions in order to study changes in the spectral coefficients of reflection in the visible light range with phase of rotation of the asteroid. The latest observations were performed on the two-meter reflector of Shemakhinskaya Astrophysical Observatory using a scanning photoelectric spectrophotometer under program control. Spectra of Vesta in the 4860-6860 A band were produced on 8 to 9 October, 1986, with spectral resolution of 24.8 A. Since only two independent spectra were obtained, the relative error in mean values of reflection coefficients was 8-10 percent. The spectrophotometric observations showed that the hemispheres of the asteroid differ in their mineral composition. The spectra of Vesta did not coincide with basalt achondrites in the 0.50-0.55 μm range. The 0.55 μm band was not recorded, rather a band at 0.54 μm. The positions of the minima of bands in the 0.51-0.54 μm range differed in Vesta spectra from different oppositions, which may or may not be genuine differences. One hemisphere apparently has more complex mineral ensembles than the meteorites, possibly containing manganese or iron ions, indicating a higher degree of oxidation of matter on the surface of Vesta than was previously thought. The spectra do not directly indicate presence of diogenite-type material on the surface. Figures 4, references 24: 9 Russian, 15 Western.

Likelihood of Contact With Extraterrestrial Technological Civilization

18660194 Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 2, Mar-Apr 88 (manuscript received 7 Jan 86) pp 433-435

[Article by V. M. Lipunov, State Astronomical Institute imeni P. K. Shternberg]

[Abstract] The absence of "wonders of space" is the principal argument against the existence of extraterrestrial intelligence, and it can have two explanations: 1) our civilization is unique, or 2) The characteristic lifetime of a technological civilization, t, is much shorter than cosmological time, T. The author believes that it is not yet possible to make a choice between these possibilities. Assuming that we do not occupy a privileged position in the universe, the corollaries resulting from the second possibility are discussed. It is clear that the reasons for the existence of finite time t must be of a universal nature. If t is much less than T, then the number of civilizations existing simultaneously in the galaxy was stabilized long ago and can be computed by the formula $N = \nu t$, where ν is the rate of birth of civilizations. It is assumed that $\nu = p\nu_*$, where ν_* is the rate of birth of stars of solar mass and p is a dimensionless coefficient which is much less than one. Contact, or exchange of information, between civilizations will be possible if the mean distance between civilizations, d, satisfies an inequality taking into account the radius and thickness of the galactic disk. The relationship between the number of civilizations in the galaxy, N, and the characteristic lifetime, t, is plotted. Civilizations positioned at a mean distance of d, below the hyperbola plotted, in principle cannot exchange information. An upper estimate is presented for the likelihood of contact. Because the characteristic lifetime, t, for civilizations of the terrestrial type does not exceed a few characteristic times for exponential development, τ, contact is practically impossible. Moreover, the number of civilizations existing simultaneously in the galaxy is much less than 4000. Figures 1. References 6: 2 Russian, 4 Western.

Designer Describes "Energiya" Rocket System

PM1008131788 Moscow PRAVDA in Russian 30 Jul 88 Second Edition p 4

[Article by G. Gubanov, chief designer of the "Energiya" rocket system: "'Energiya' Airborne!"]

[Text] The la unch of the new "Energiya" Soviet heavylift launcher has aroused enormous interest among specialists and the general public. This is understandable—with the creation of such a rocket we are opening up unique opportunities for expanding space research.

I should probably start by explaining that we are talking about a new general-purpose rocket system. It will make it possible to place in low-earth orbit a payload of more than 100 metric tons, both in the form of a shuttle—which is currently being actively prepared for its first launch—and in the form of large autonomous spacecraft.

For the third stage special rocket boosters with their own control system can be used to carry the payload. On this basis tasks can be resolved linked with placing spacecraft in geostationary orbit [GEO] or on trajectories to the moon and the planets. Spacecraft weighing around 18 metric tons can be placed in GEO, while craft of around 32 metric tons can be placed on lunar trajectories, and up to 28-metric ton payloads can be placed on Martian and Venusian trajectories.

This flexibility is an important feature of "Energiya," since it is a launcher rather than a booster-equipped orbiter.

The "Energiya" launcher comprises a two-stage "package" of four longitudinal first-stage boosters around a central second-stage core and an asymmetrical payload position. Launcher lift-off weight can be up to 2,400 metric tons. Each first-stage booster is fitted with a four-chamber liquid-propellant rocket motor burning liquid oxygen and hydrocarbon fuel. First-stage motor thrust is 740 metric tons at the earth's surface and 806 metric tons in a vacuum. The second-stage burns oxygen-hydrogen fuels and has four single-chamber liquid-propellant rocket motors each with a thrust of 148 metric tons at the earth's surface and 200 metric tons in a vacuum.

First- and second-stage motors are fired almost simultaneously just before lift-off. Total lift-off thrust is around 3,600 metric tons. The method adopted makes it possible to avoid the problem of firing motors in weightlessness, and additionally enhances reliability.

Upon fuel depletion the first-stage boosters separate in pairs from the rocket, then split up and land in the designated area. They can be fitted with reentry and landing equipment housed in special compartments. They can be reused following diagnostic, preventive-maintenance, repair, and restoration work.

The central core—the second stage—separates after suborbital velocity is reached and lands in a designated area of the Pacific. This procedure was selected in order to prevent near-earth space becoming littered with large discarded launcher fragments. The boost to orbital velocity is supplied by motors on the payload, the orbiter, or the booster unit. In other words, they act as a third stage.

The modular assembly of the rocket, its transportation on a special transporter from the Vehicle Assembly and Test Building to the launchpad, and the provision of power, pneumatic, hydraulic, and electrical connections with the launcher are conducted using a mobile launcher-mating unit, which remains at the launch complex after launch and is reusable.

Another fundamental feature of the "Energiya" launcher is its construction on the basis of the second-stage unit and standardized first-stage modules. This makes the system flexible and allows for the subsequent development of a number of promising heavy-lift and medium-lift boosters with varying payload capacities depending on their number of modules.

The road to flight testing of the new launcher was paved with many complex scientific, engineering, and organizational problems. The efforts of hundreds of design bureaus, plants, research centers, and construction, installation, and operations enterprises were pooled in the development of "Energiya." Dozens of ministries and departments, the USSR Academy of Sciences, and union republic academies made their contribution to this work.

The powerful rocket required the use of high-energy fuels, including liquid oxygen cooled to minus 186 degrees Celsius as the oxidizer and liquid hydrogen cooled to minus 255 degrees as the fuel for the second stage. Special structural materials working at cryogenic temperatures and with considerable strength were developed and used in the manufacture of the tanks, supply lines, and some of the hydraulics. A number of new types of high-strength steel and aluminum and titanium alloys were introduced. New thermal-protection and thermal-insulation coatings were developed. In all, new materials make up more than 70 percent of the "Energiya" launcher's unfueled weight.

The technology has been assimilated for the manufacture of large "wafer" structures for the tank shells and for the assembly of large-diameter units using electron-beam and pulse welding on an industrial scale. Wafer-type shells are currently used quite extensively in rocket equipment.

The problem of transporting tanks and central core compartments 8 meters in diameter and weighing more than 40 metric tons from the manufacturer to the point of assembly has been solved. A specially modified heavy aircraft is used, which has made possible the world's

first-ever regular operations in transporting structures of enormous dimensions—the diameter of the cargo is almost 2 and ½ times greater than the aircraft cross section.

One of the most complex and fundamental problems was the development of reliable and powerful sustainer motors for both the first and second stages. A great deal of attention is traditionally devoted in the Soviet Union to the development and improvement of liquid-propellant rocket motors. The RD-170 motors, which are standard for new-generation launcher first stages, including "Energiya," were built in the most economical and compact layout—in which the gas used in the turbine is ignited in the main combustion chamber—and have produced a record performance in their class in terms of thrust and specific pulse. They are equipped with high-power turbopump units (more than 250,000 horsepower).

The development of reusable high-thrust sustainer motors using high-energy fuel components for the "Energiya" booster's second stage was a considerable achievement for Soviet rocket construction. The designers managed to ensure high performance characteristics with minimal gas-dynamic losses, regenerative cooling, and durability of the materials used in a liquid hydrogen environment.

For directional control in the boost phase the sustainer motors are equipped with a precision electrohydraulic steering system (with an accuracy of up to 1 percent of the range of movement). They develop a force of up to 50 metric tons in each rolling plane of the first-stage sustainer motors, and more than 30 metric tons in the rocket's second stage.

Wide-ranging and multifaceted problems were solved by setting up an autonomous on-board rocket control system based on a multi-unit computer complex. Pride of place was given to the development of software and control programs both for standard flight conditions and for cases of individual systems failures. More than 500 emergency situations were analyzed and algorithms found to compensate for them. These questions were researched on experimental installations, and also during testbed firings.

In general the closest attention was paid to ensuring "Energiya's" reliability and survivability. The provision of backup systems was stipulated for the main vitally important systems and units, including the sustainer motors, steering instruments, turbogenerator power sources, and pyrotechnics. The autonomous guidance complex also has inbuilt component and circuit redundancy. The special emergency protection devices which diagnose the condition of both stages' sustainer motors and trigger an immediate cutout when a failed unit starts malfunctioning are a new feature of the rocket. In addition, the rocket is fitted with efficient fire or explosion warning systems.

The measures that have been taken minimize the likelihood of a dangerous breakdown during launch. So if an abnormal situation arises, the rocket can continue controlled flight even with a first- or second-stage sustainer motor shutdown—which, incidentally, is impossible using solid-fuel boosters such as on the "space shuttle" system. In abnormal situations during the launch of a manned orbiter the constructive measures built into the rocket make it possible either to place the craft on a low "single-orbit" flight path following the orbit of satellites and subsequently landing at an airfield, or to carry out a maneuver to return to the boost phase, landing the craft on a strip located near the launch complex.

It is well known that it is impossible to create a complex technical system that will work absolutely perfectly. That is why, if the launcher fails during the launch of an unmanned payload and it proves impossible to place the spacecraft in orbit, the rocket is guided into special zones along the flight path where the possible damage will be minimal—but the likelihood of such situations is fairly low.

Thus, by the time of the first launch of "Energiya" a large program of research, development, and experimental work had been completed. In all, more than 200 experimental installations, 34 large structural assemblies, and 5 full-size items were created for this purpose, and the total number of tests carried out exceeded 6,500. Moreover, the modular part of the first-stage unit was successfully flight-tested in the launch of a new medium-lift launcher. The main aim designated before its first test flight was to obtain experimental data on the serviceability of the design of the rocket itself, its propulsion systems, other on-board systems, and full-scale launch conditions—that is, data which could not be obtained during static tests were received in full. The correctness of the plan and design solutions and the strategy and scale of ground development were confirmed. The operation of all on-board systems was shown to be highly accurate.

The final phase of the launcher's work, in which it was necessary to ensure the conditions for separation of the payload—in this instance, a dummy spacecraft—also went smoothly. Unfortunately, a faulty circuit in one of the on-board instruments in the dummy spacecraft prevented it from reaching the planned velocity and entering orbit after separation.

Positive results from the first test of this class of system—a test which was the result of a range of purposeful scientific research, planning, and engineering work—could not be mere chance; only a malfunction could be chance. The specialists are well aware of that. On the contrary, failures at the start of flight testing would not have made it possible to claim that the system was viable—there would still have been room for doubts about whether there were any fundamental shortcomings.

Random breakdowns in such complex technical systems may occur mainly because of unexpected and undetected defects during assembly and operation. In this connection all further development currently boils down to stabilizing manufacturing techniques and improving quality-control methods and their completeness.

The "Energiya" launcher is a component of a rocket system which includes—apart from the rocket itself and the payload—a ground complex unique in its scale, capabilities, and level of technical equipment, which provides training and carries out the launches. Its distinguishing feature—also inherent in the rocket itself—is its high level of automation. The launch center computer complex, which controls many units and mechanisms taking part in launch preparations, cooperates with the on-board part of the guidance system, which in turn controls the state of all launcher systems.

A multipurpose launcher testbed was designed and commissioned as part of the ground complex in order to test under ground conditions the first- and second-stage units and the "package" as a whole, firing each stage's sustainer motors for virtually their full burn time. This large-scale installation (the plume deflector shield, for instance, is located more than 40 meters below ground level, and the lightning conductors standing alongside the launchpad rise to 225 meters) equipped with a large amount of necessary technical and technological systems can also be used as a launch complex. It was from here that the first "Energiya" launch took place.

The specially developed cryogenic systems for fueling the launcher with cooled hydrogen and oxygen employ new engineering principles. All fueling processes are automated and based on modern computer equipment.

We are at the start of the flight-test stage of a complex rocket system. What problems will still have to be solved? The most immediate problems are linked with making the design reusable. The desire to reuse such a unique rocket is quite natural and understandable. At the present stage the system is undoubtedly expensive. The main stimulus for further improving and developing new launchers is the need to reduce the cost of placing a unit mass of payload in orbit (the so-called unit launch cost). This value characterizes the sophistication of the launcher. Analysis shows that in the future expendable space transportation systems will lack the prerequisites for markedly reducing unit launch cost. A radical solution to the problem of reusable launch vehicles lies with the appearance of a new class of transportation system—spaceplane systems. But here a great deal depends on materials technology—new superlight and durable structural materials are needed.

The main task of the day is to land an orbiter—and in the future, individual units and stages—automatically without using pilots. Currently automated flight from takeoff to landing is possible in aircraft systems, such as the TU-204 medium-haul airliner, for instance. The problem is an urgent one.

The role of manned missions on launchers of this class is not yet fully clear—that is the opinion of many specialists. It would be inappropriate to blindly copy aviation in this area—space technology has developed in its own way. Initially automatic craft were launched into space, and it was only later that man followed them. In the future space will mainly be a field for automatic spacecraft and transportation systems. Clearly, man's role will be linked with research and specific work on servicing and repairing systems.

Diagnosis of the condition of structures is a fundamental problem linked with reusability. The current standard of diagnostic methods does not yet make it possible to forewarn of a possible accident caused by hidden defects that arise in the process of operation. A reliable and accurate assessment of service life on the basis of controls using objective and nondestructive methods is a task which we will have to learn to resolve.

There are longer-term problems involved with working out avenues for creating standardized modules and units for future superheavylift launchers based on "Energiya" in order to use near-earth space in the interests of the national economy, to organize industrial production in space, to research the moon, Mars, and other planets, and to eventually organize an international expedition to Mars. There are many problems, but it can already be claimed today that the Soviet Union has laid the foundations for their resolution.

"Energiya" Booster Launch Systems

18660182a Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 15 May 88 p 4

[Article from TASS by V. Karashtin, doctor of technical sciences: 'Thus "Energiya" Is Launched'; first paragraph is source introduction]

[Text] *A year has passed since the day the new space transportation system was launched. In the Soviet and foreign press, scientists have noted this event as a qualitatively new stage in the exploitation of outer space.*

The two-stage Energiya rocket, with its own weight of more that 2,000 metric tons, can place into space orbit a payload of more than 100 metric tons. The booster consists of one central and four lateral units. The height of the complex is 60 meters, the maximum cross-section dimension is 20 meters and the diameter of the second stage is 8 meters. The central unit has four engines with a thrust of 200 metric tons each. Liquid hydrogen and liquid oxygen are used in it as the propellant components. The lateral units' engines operate on an oxygen-carbon fuel. The thrust of each is 800 metric tons. There are no more powerful propulsion systems in the world today. All this has placed exceptionally high demands on the process of the rocket's pre-launch ppreparation and launching.

One of the main features of the technological schedule for the preparation of the Energiya for launching is the large number of simultaneously occurring processes and the necessity of their strict synchronization according to time. This required the concise operation of not only the launch complex's systems, but also the cosmodrome's other ground complexes. First of all, providing the launch with reliable, quality electric power from two independent sources which back each other up. The complexity of the task lies in the unusually large power consumption of the systems which ensure the launching, which is equal to the electricity consumption of a rather large city.

TThe launch complex is a number of structures which are spread out over a large area—this is caused by the requirements for their mutual safety in all the possible unusual situations in the event of a rocket mishap during the launching.

The launcher, from which the Energiya is launched, is a reinforced concrete structure. Located in it are the holding devices for the launch vehicle and the systems for attaching the pneumo-hydraulic and electric lines. Below them is a trough for discharging the gas jets during the rocket's firing. In order to show the enormity of the complex, it is enough to say that it is possible to place an average city block containing 12-story buildings into this trough.

Complicated problems had to be solved during the development of the fueling systems—particularly for the supercooled liquid hydrogen. This was the first thing handled. The storage tanks for the cryogenic fuel components—liquid hydrogen and oxygen—are spherical tanks with shielding vacuum insulation. Taking into consideration their special explosion hazard, the tanks are placed at a significant distance from the launch facility. During the Energiya's fueling, it is necessary to exercise simultaneous control over more than 4,000 actuators and to maintain with a high degree of accuracy the average temperature of the supercooled liquid hydrogen without allowing a fluctuation in the component level in the tank of more than 10 millimeters.

All the pneumatic, hydraulic and electric connections from the ground systems to the launch vehicle are made through its face and lateral surface by means of the fueling and venting tower. There are movable platforms on it, on which the lines for fueling and venting and also the electric cables for "ground-to-ship" communication are laid out. Prior to the launch, these platforms are moved away one at a time and the last one moves away after the engine ignition and the start of the rocket's movement. Its mass is more than 20 metric tons, while the removal time is a few seconds. Thus, it is necessary to slow down this mass and stop it smoothly in a matter of calculated moments. After a serious engineering study and a large volume of experimental work, this problem was successfully solved.

The launch complex's automated control system was built according to the hierarchical principle and has three levels. The total volume of commands and received signals is more than 100,000. The first level is associated directly with the rocket and fulfills the role of "director" with regard to the other levels' systems, which begin functioning only after receiving commands from the first level's system.

Special attention during the preparation of the first launch was paid to safety matters. This is understandable, if it is recalled that the fuel components are liquid oxygen and liquid hydrogen. It is not necessary to explain to an engineer the danger of their proximity. Therefore, in the rocket and at the launch complex, design, technical and organizational measures were adopted to preclude their mixing. In the launch vehicle's compartments, where there could be hydrogen and oxygen vapors, quick-response gas analyzers were installed, which instantly signal when there is an increase in the concentration of gases.

The specialists are assisted in preparing for a launch by a technical television system. It provides for remote inspection of practically any external angle of the rocket and the components of the ground equipment, while its television screens are located at all sites where operators work.

Rail Transport Facilities at Baykonur Cosmodrome

18660218 Moscow GUDOK in Russian 12 Apr 88 p 4

[Article by V. Rostovtsev, correspondent (Baykonur Cosmodrome)]

[Abstract] An article published on the occasion of Cosmonautics Day recounts a recent tour of the Baykonur Cosmodrome and the nearby city of Leninsk. Particular attention is devoted to the history and present-day facilities of the cosmodrome's rail transport system, which is said to employ hundreds of specialists and take in almost 500 kilometers of railroad lines, including special tracks capable of withstanding enormous weights.

V. Kirilenko, head of the cosmodrome's railroad department, accompanied the author of the article on his visit. An account is given of an operation in which a spaceship and its launch rocket were hauled from an assembling-and-testing building to a launching area. The rocket-spaceship complex was transported on a special flatcar pulled by a small TEM2 diesel locomotive, which moved its load into position with a precision of 3-4 centimeters at the launching area. Vladimir Gavrilyuk, head of the cosmodrome's locomotive depot, mentioned that the railroaders expect to receive powerful locomotives intended especially for hauling "Energiya" launch rockets.

A photograph is given showing a locomotive and a flatcar stopped at a launching area. The flatcar is carrying a "Soyuz" spaceship.

FTD/SNAP

New Space Support Ship 'Akademik Nikolay Pilyugin' Under Construction

18660216 Leningrad LENINGRADSKAYA PRAVDA in Russian 13 Apr 88 p 3

[Article by L. Ivankin]

[Excerpt] A new scientific research vessel of the USSR Academy of Sciences is named for academician N. A. Pilyugin, an outstanding designer of rocket and space technology. The ceremonial laying of this vessel's keel took place at a building slip of the Leningrad Admiralty Association yesterday.

The ship is the lead vessel of a series that is new in principle. It is intended for spacecraft control and tracking systems.

This giant scientific ship, which was developed at the Baltic Ship Designing Bureau by a creative team under the direction of chief designer B. P. Ardasov, marks an important stage in the further exploration of space. It will carry improved navigational and scientific equipment, and maximum comfort will be provided for the work of its crew and of scientists and specialists.

Cosmonauts G. T. Beregovoy and O. G. Makarov took part in the laying-down ceremony.

The "Akademik Nikolay Pilyugin" will set out on its space odyssey from the banks of the Neva.

FTD/SNAP

BPChL-1 Satellite Telemetry System

18660217 Moscow NTR: PROBLEMY I RESHENIYA in Russian 8-21 Mar 88, No 5, p 2

[Text] Lvov. A satellite frequency telemetry system, the BPChL-1, has been developed at the Ukrainian Academy of Sciences' Physical-Mechanical Institute imeni Karpenko. It is intended for transmitting the signals of 10 onboard instruments via a single communications line, on a real-time scale.

The system can be used in tests of moving objects and gathering and processing geophysical information, and also in general-industrial telemetry systems which have to meet requirements for high precision, capacity and noise immunity, compact dimensions, and low weight and power consumption. The annual economic benefit from introduction of a single system-unit is 111,000 rubles.

FTD/SNAP

Benefits to National Economy from Space Research

18660196 Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 88 pp 15-19

[Article by Yu. P. Kiyenko, candidate of technical sciences and general director of Priroda State Center; "Space Research—For the National Economy"; first paragraph, in italics in source, is introduction to article]

[Text] Soviet space researchers have traveled the path from the first visual observations made from orbit to the systematic study of the Earth from space, the creation of satellite communications and navigation systems, and the development of space technology. This article addresses some of the achievements of the thirty years of the space age.

Orbiting in space today are dozens of spacecraft—some manned and some unmanned; some returning to Earth after operating in outer space, while others are longtime satellites of our planet and other planets of the solar system; some forging the way to deep space, while others perform tasks of a more traditional nature.

It is not easy to enumerate all the things that space technology does for the various fields of human activity. And of course, it is not exotic and extravagant solutions of scientific and applied problems via space technology that attract scientists and specialists.

Many fundamental scientific problems and applied engineering tasks can be solved with space equipment alone, or at least the use of space equipment is obviously better (materially, financially, and in terms of time) than methods that involve traditional solutions. Thus, based on the potential of spacecraft, astronomy is undergoing a rebirth (Zemlya i Vselennaya, 1984, No 5, p 36—*Ed.*). The atmosphere has greatly limited man's attempts to look out as far as possible into the reaches of the universe. The astronomical observation gear that has been taken into space has expanded research potential considerably. Interplanetary stations have enabled scientists to make direct studies of remote celestial bodies—the Moon, Venus, Mars, and other planets of the solar system—and have helped us to study Halley's Comet up close.

Rocket probing of near and deep space has made feasible such developments as a detailed study of the magnetic field and the magnetosphere of our planet, direct measurements of solar wind parameters, a study of the properties of the plasmasphere and of the plasma in near-Earth space, and the solution of the mysteries of the auroras.

Impressive were the first steps and promising are the developments of space technology that enables the industrial use of space (Zemlya i Vselennaya, 1986, No 2, p 2—*Ed.*). Weightlessness, the vacuum and radiation of space, and the unusual nature of the processes of mass and heat transfer find application in the creation of new materials and medical preparations. With weightlessness, properties of liquids such as the action of the forces of surface tension have new effects, which makes it possible to conduct containerless processing of materials. The absence of convection when there is molecular diffusion opens grand possibilities in the growth of crystals and the manufacture of semiconductor materials. Only in weightlessness has it become possible to synthesize high-quality homogenous mixtures from components of varying density and to obtain highly pure materials.

The world's first engineering experiment in space was done aboard the Soyuz-6 in 1969, to study the fusion and welding of metals. Later, processes such as the derivation of high-quality crystals, metal alloys, and biological preparations and the deposition of metallic coatings were studied aboard the Salyut and Mir orbital stations.

Communications satellites are launched into space on a regular basis (Zemlya i Vselennaya, 1986, No 3, p 37—*Ed.*). They have taken the place of enormous stretches of telephone, telegraph, and radio broadcast cable systems and radio relay lines and have taken upon themselves the provision of radio communications with remote areas, polar villages, maritime vessels, and orbital stations. Three Molniya satellites and several dozens of ground stations were already in operation in the early 1970s. These satellites are used to transmit photographic copies of central newspapers, facsimiles of weather maps, and radio and television programs and to conduct two-way telephone and telegraph communications. From an altitude of 36,000 km, Raduga and Gorizont satellites provide stable radio communications and television broadcasts to Siberia, the Far East, and the Arctic. Artificial earth satellites are also used for communications with foreign countries.

The refinement of a space navigation system began with the launch of Cosmos-1000, although experiments in this area began back on the first spacecraft (Zemlya i Vselennaya, 1987, No 4, p 15—*Ed.*). The need to create such a navigation system was due to the development of navigation; specifically, it was in the interests of improved safety of seagoing vessels. The services of satellite navigation equipment were used, for example, when the nuclear icebreaker "Arktika" reached the North Pole in 1977 and when the "Sibir" reached it in 1987. The system comprises several satellites operating in circumpolar orbits, monitoring and measurement centers, and receiving equipment aboard ships. Computers aboard a ship determine the ship's geographical coordinates from the parameters of the relative positions and movements of the ship and the satellite. The need for space navigation equipment will continue to increase, and the the accuracy of measurement of coordinates will continue to grow. Such equipment is needed to determine the location of geodesic points—it is becoming unnecessary to

build multiple, expensive trigonometric points or to perform labor-intensive angle observations and linear measurements—and the work can be done in any weather.

We have been conducting **satellite geodesy** research in this country since 1962. Artificial satellites have been simultaneously photographed against the stars by several ground stations, and then the angular elements of a triangulation network have been determined from the photographs, with distances between the points in the thousands of kilometers. A side in satellite triangulation was hundreds of times longer than the distance between points in a traditional geodesic network.

Specialists from a number of countries have taken part in the creation of a satellite-based system of search and rescue (Zemlya i Vselennaya, 1983, No 6, p 8; 1985, No 2, p 1—*Ed.*). The system is of assistance to the crews and passengers of maritime vessels and aircraft, as well as to searchers who have special radio buoys. The Soviet project KOSPAS got under way in 1982, when the first rescue satellite, Cosmos-1388, was launched into a circular orbit nearly 1,000 km high. A similar system backed by the United States, Canada, and France and compatible with our domestic system, is called SARSAT. The combined projects are called KOSPAS-SARSAT. They provide for the exchange between national centers in Moscow, Ottawa, St. Louis (U.S.), and Toulouse of the information reported by the satellites.

Here is an example. After it began operation, Cosmos-1388 received an SOS signal from the crew of an airplane that had crashed in British Columbia. In September 1982, the Canadian Press agency reported that "three Canadians from the province of Ontario, whose airplane crashed in British Columbia last week, owe their lives to the Soviet satellite." The airplane had made a forced landing in an unpopulated region, and its radio transmitter had been damaged. Nevertheless, a radio buoy signal was received by the Soviet satellite, and within hours a report on the accident and on the location of the people involved arrived in Canada from the USSR. The satellite's accuracy in determining the coordinates of the accident was, as the Canadians attested to, amazing. Since that time, the KOSPAS-SARSAT system has saved a great number of lives.

The operation of Meteor system satellites is of great importance to the World Meteorological Organization and to the reliable forecasting of weather conditions in the country (Zemlya i Vselennaya, 1977, No 5, p 80—*Ed.*). The system has been operation since 1967. At present, it includes spacecraft, with television equipment for studying the atmosphere and ground and sea surfaces, and ground stations for receiving and processing weather data and images of the Earth made at altitudes of around 900 km.

The reliability of weather forecasts is increasing because of satellite information, and although man cannot yet control the weather, tracking of weather conditions is already saving him 500-900 million rubles a year. It is virtually impossible to gather such volumes of the raw meteorological data needed for forecasting with other, nonsatellite equipment. After all, predicting the weather for a given spot for a 24-hour period requires meteorological information covering a radius of 3,000 km, and a forecast that is to cover several days is reliable only if meteorological information is gathered for an entire hemisphere. That task is performed successfully from orbital altitudes. A Meteor satellite, for example, is capable of seeing 20 percent of the globe in just one circuit.

Traversing a comparatively short distance, **space-based environmental management** envelops many fields of study and management of natural resources. Remote satellite sensing of the Earth (from a distance of hundreds of kilometers) in various ranges of electromagnetic waves is being used with success to solve hundreds of problems associated with the national economy.

In the mid-1980s, space data was being used in our country by as many as 900 scientific-research, planning, and exploration organizations from 22 ministries and departments. Every year, they have at their disposal nearly one million units of various kinds of remote sensing materials.

The need for remote sensing has led to the creation of a special system for the study of natural resources and for the monitoring of the natural environment. The system comprises unmanned spacecraft and manned orbital complexes, ground-based equipment for receiving and processing the information that is derived, and an extensive network of remote sensing data consumers.

The use of space-based equipment in the interests of environmental management has revolutionized the study of natural resources and the environment. Altitude and speed of flight and virtually unlimited visibility have made it possible for satellites to obtain huge amounts of comprehensive information. Created on the basis of this information is a highly productive method of research that follows the principle of going from the general to the specific. Employing the usual means to create a map of Antarctica, for example, once required outfitting expensive expeditions and spending years doing aerial photography and performing astronomical and geodesic measurements in the severest of conditions. Today, using space-based equipment for these purposes, we are creating detailed maps in short periods of time, even though we are thousands of kilometers from the area under study and are working in comfortable conditions.

Space-derived information is universal and has multiple uses. It makes it possible to comprehensively study natural resources, a practice that our country was the first to develop and use on an industrial scale. This is

particularly important to intensive economic development in areas where new regional-production complexes are being built and existing ones are being renovated and to the development of optimal variations of the economic use of the natural potential of a given region.

The comprehensive study of natural resources based on satellite sensing is highly efficient in technical and economic terms. This is being confirmed by the results of work that is being done along the Baykal-Amur Railroad and in areas like the Tadzhik SSR, the Kirghiz SSR, the Uzbek SSR, the Kalmyk ASSR, the Stavropol Kray, the Kalinin Oblast, and some parts of the Yakutsk ASSR. In the Central Asia area, for example, more than 250 photoanomalies have been discovered that hold promise for oil and gas exploration. Large tracts of land suitable for the development of irrigation farming have also been found, as have unused pastures for livestock breeding. We have also been able to evaluate and label areas according to the degree of danger they present in terms of mud flow, avalanche, rock slides, and earthquake; in addition, we have been able to produce a comprehensive picture of our water resources and designate numerous ring structures on maps and depict lines of heretofore unknown or unrefined fractures in the Earth's crust. Specialists have also identified mineralization patterns.

The comprehensive, space-based study of the comparatively small area of the Kalmyk ASSR has made it possible to divide it into new petrogeological districts. This has led to the predicted several-fold increase in oil and gas reserves. At the same time, 14 heretofore unknown regional geological lineaments have been identified, along with more than 50 local lineaments. Images produced by satellites of the Cosmos series have made it possible to map the boundaries of the ancient river valley of the Volga, which, as interpreting shows, once emptied into the Caspian Sea from the west, and not from the north, as it does now. Also discovered in that region are more than 20 areas that hold promise in the search for fresh groundwater.

Space-derived information enables the identification of negative processes due to the exploitation of natural resources. In that same Kalmyk ASSR, overgrazing is intensifying the deterioration of pasture lands, and desertification is expanding.

This kind of comprehensive study of natural resources either has already been conducted or is under way or being planned in many different regions of the country. It will enable us in the future to study the dynamics of the natural environment and to use natural resources efficiently.

Using information derived from space and employing ground-based systems for the optical and electronic processing of data and mathematical models of the natural environment, we can create regional and statewide systems for the regulation of resource use. But there are also still many unresolved problems. Among them are the adoption of new varieties of remote sensing—including all-weather radar studies of land—and research of the even less studied sea and ocean water bodies. Properly solving such problems will require the creation of an industry all its own for processing space-derived information with high-speed computers, the development in sectors of the national economy of systems for specific types of processing of space-based photography, and the training of personnel in the field of space-based environmental management.

The space-based study of the natural potential of the Earth touches each and every one of us more closely than any other area, perhaps. This area of space study can become an arena of fruitful international cooperation. In attaching immense significance to the peaceful development of near-Earth space, our country has repeatedly come forth with initiatives to use the achievements of our domestic space science and technology for the good of all mankind.

At present, the USSR is working with many countries in various areas that use space equipment for scientific research and for solving applied problems. Therein lies the humane direction of the development of Soviet cosmonautics, an alternative to the militarization of space and to the notion of "star wars."

The noble aim of Soviet cosmonautics is to serve peace and progress for the good of all mankind.

UDC 551.465.5:629.78

Nature of Transverse Jets Detected on Satellite Images in Marginal Ice Zone

18660198a Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 4 May 87) pp 3-10

[Article by A. I. Ginzburg, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] The existence of a natural boundary between the open water and ice is responsible for the clearly pronounced frontal character of marginal zones of the oceans and seas adjoining the ice caps. The analysis of satellite images has revealed a type of current characteristic of marginal zones—relatively narrow transverse jets from several to approximately 100 meters long, extending from the ice edge approximately along the normal to it in the direction of the open sea and not infrequently terminating in a vortex or vortex dipole. A picture of this phenomenon is presented and various possible mechanisms for the formation of marginal transverse jets are discussed, based on presently available satellite and meteorological data. The phenomenon can be assumed to be fairly general and associated with some physical process at the ice edge, in that marginal transverse jets are characteristic both of a stationary ice cap and shore ice or a floating ice mass existing only in the winter-spring season. Practically all cases have been observed

during the period of intense thawing of the ice. The jets can be both in the form of straight lines or slight curves. The jets have been observed both in the vicinity of packed ice and near the edges of open pack ice. The rate of flow in the jets reaches 40 to 50 cm/s and the jets last up to 10 days. Systems of transverse jets have been observed, e.g., four structures 5 to 15 km wide 25 to 40 km apart from one another. The dimensions of the jet and vortex parts of the structure are often of the same order of magnitude. It is demonstrated that not one of the hypotheses discussed in the literature consulted satisfactorily explains the phenomenon. It has not been ruled out, however, that the mechanism leading to the formation of marginal transverse jets is associated with marginal upwelling. Upwelling is accompanied by the appearance of a front at the ice edge whose instability can be decisive for this phenonemon. The picture of the phenomenon presented here has exceptionally close similarities to that of jets detected in coastal upwelling. The topography of the floor and the configuration of the ice edge can be intensifying factors. In order for waters of upwelling origin to be carried in the form of jets over distances of dozens of kilometers their density must be lower than that of the underlying waters. The presence near the edge of large amounts of water freshened because of the thawing of ice can be the only source of the transformation of the warm, salt water raised to the surface. Marginal upwelling in combination with the melting of broken ice is responsible for the formation of the jets observed. Figures 4; tables 1; references 18: 10 Russian, 8 Western.

UDC 551.46.06:528.8.041

Remote Optical Studies of Breaking Fields of Gravity Waves of Developing Sea Wave
18660198b Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 2 Oct 86) pp 11-22

[Article by I. V. Pokrovskaya and Ye. A. Sharkov, Institute of Space Research, USSR Academy of Sciences, Moscow]

[Abstract] The characteristics of the breaking fields of sea waves have practically not been studied experimentally. The authors made the first attempt at a discrete statistical analysis of breaking fields from optical images in 1986, 1987, based on a model of an integral point random process. These studies indicated that the breaking random process, under conditions of maximum fetch, belongs to the class of processes having stationary and independent increments with uniformly distributed and independent (i.e., without an aftereffect) wave breaking centers. Here it is demonstrated that this model of a Markov random field can be extended to the breaking fields of sea waves at various stages of their development, including the earliest stages of interaction between the sea surface and the wind stream. Aerial photographs were taken of the sea surface from on board an Il-14 airborne laboratory using the AFA-100 aerial photography equipment. Four series of large-scale photographs on a scale of 1 : 4000 were taken of the disturbed sea surface with the presence of foam from an altitude of 400 m. A straight-line flight was made from south to north along the general direction of increasing disturbance. The individual films were grouped into individual collections of samples according to various degrees of interaction between the wind stream and surface. Only parts of frames clearly containing foam structures were analyzed. Each was represented by a point on a tracing transparency, so that a limited section of the sea surface was represented by a set of points, or centers, representing the location of breaking waves at a certain fixed point in time. The number of single foam centers was counted for all four series and a matrix point field was formed, taking into account the south-north direction along the general direction of the disturbance, the west-east direction across the general direction of the disturbance, and the number of the series of photographs. The matrix field represents a field of increments of an integral random process. The space characteristics of this field are discussed. The technique represents a new procedure for processing optical images of point (discrete) random fields for the purpose of obtaining information on the correlation properties of a point field. The experiment demonstrated that the stochastic model of the breaking of gravity waves on the sea surface can be represented at all stages of the development of disturbance as an integral random space field with independent increments and uniformly distributed independent breaking centers. Figures 4; tables 3; references 25: 23 Russian, 2 Western.

UDC 528.813

Features of Correlation Structure of Spectrum of Optical Signal Coming From Remotely Sensed Objects (Using Sea Surface as Example)
18660198c Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 14 Aug 85, after correction 2 Feb 87) pp 23-30

[Article by A. Popa, B. M. Balter, M. Ganzorig, V. V. Yegorov and R. Kachinski, Institute of Space Research, USSR Academy of Sciences, Moscow; Institute of Geodesy and Cartography, Polish People's Republic Academy of Sciences, Warsaw]

[Abstract] The spectral characteristics of remotely sensed objects depend on a great number of factors governing the interaction of light waves from the sensed environment. Some of these factors are of a band-selective nature and others of a panchromatic nature. The percentage contribution to the overall spectrum of each spectral pattern that can be matched with a specific factor is usually a random quantity or a random function of time. Correlation analysis is well suited to studying these patterns. Variations in the size of any factor usually result in correlated variations in the spectral reflectance factors (KSYas) in various spectrum channels of a remote sensor such as a spectrometer. This makes it

possible to estimate the contribution of each factor and of its spectral pattern to the overall spectrum. A method is discussed here for a visual analysis of the field of interchannel correlations, using as an example data from sea surface spectrometry. It is assumed that the sensor has high resolution and that the spectral patterns of the factors studied are all band-selective without resonance features. KSYa correlation coefficients are computed between all pairs of the instrument's spectrum channels and they are mapped in X-Y coordinates, using the color as the third (Z) coordinate, in the form of lines of equal correlation coefficients, resulting in geometrical shapes in a plane. Then the characteristic patterns produced by a specific factor on account of its influence on the KSYa are looked for among these shapes. The purpose of this analysis is to evaluate the contribution of various factors to the KSYa at various wavelengths, to reveal the collection of them at work and to simplify subsequent quantitative analysis, and all this from spectral data alone, without resorting to contact measurements. The correlation patterns (shapes) expected theoretically are discussed, as well as characteristic shapes obtained in an experiment. It is suggested that the visual identification of characteristic shapes is one of the most effective methods of deriving information from a mixture of a signal and noise. The method makes it possible to identify newly detected effects from contact measurement data. It is possible that the method will make it possible to detect on the qualitative level pronounced reordering of the structure of the spectrum of a remotely sensed object without resorting to expensive, labor-intensive contact methods. Figures 5.

UDC 528.77: 550.814+629.78: 550.3: 551.24

Principles and Approaches of Integrated Interpretation of Aerospace and Geological-Geophysical Information in Studies of Buried Platform Regions

18660198d Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 12 Mar 86) pp 36-42

[Article by D. M. Trofimov, V. A. Bogoslovskiy, A. P. Borisyuk, Ye. B. Ilina, E. N. Kuzmina and M. V. Borisyuk, Moscow State University imeni M. V. Lomonosova; All-Union Scientific Research Geological Prospecting Petroleum Institute, Moscow]

[Abstract] Development of the principles of the integration of space photograph and geological-geophysical data is necessary for solving the problem of the complexity of the practical use of space photographs. The problem of the geological interpretation of the results of decoding based on an analysis of the structure of the landscape has been insufficiently worked out. Geological-geophysical charts are made on the basis of discrete initial data and the process of making them is to a certain extent subjective because several decisions are made with a low density of initial data. The problem of integration is thus to obtain maximum objective data by uniting data that are different in terms of nature and density. Space photographs make it possible to give a structural characterization of regions under study and they determine the direction and organization of subsequent geological and geophysical work. The following main principles are formulated for the integrated geological interpretation of remotely obtained and geological-geophysical data: 1) The densities of the data obtained by both approaches must be as equivalent as possible. Information obtained from space photographs on a scale of 1 : 1,000,000 with ground resolution of 50 to 80 m can be interpreted only by 60 to 80 percent if geological-geophysical data on a scale of less than 1 : 50,000 are used, but by 100 percent when larger-scale data are used. 2) A comparative estimate of the spatial and depth resolution of both kinds of materials must be made in the process of analyzing the initial data. 3) Decoding results must be interpreted on the basis of the multileveled correlation of remotely obtained images and geological-geophysical data based on the shape, dimensions and position of the objects studied. 4) The nature of objects revealed in the process of the decoding of remotely obtained data is established in the process of successively correlating these data with geological-geophysical data from the most studied surface structural systems and levels to the less studied deep ones, in the following order: remotely obtained photographic image - topographical image - morphological anomaly - physical geological model - structure. The idea of the degree of contrast of the values of the data to be analyzed is introduced as a unique criterion making it possible to make a comparative evaluation of the various data used in the process of integrated interpretation. This criterion is applied to data obtained by both approaches on the Streletskiy section through the Medvenskaya structure in the area of the Kursk Aerospace Proving Grounds. The determination of contrast values according to the principles presented makes possible the integrated automated processing of areospace and geological-geophysical data. Figures 2; tables 1; references 7 Russian.

UDC 528.813

Distinguishing Contributions of Earth's Surface and Atomsphere to Outgoing Radiation

18660198e Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 28 Oct 86) pp 58-66

[Article by A. K. Gorodetskiy, Institute of Space Research, USSR Academy of Sciences, Moscow]

[Abstract] A technique is suggested for making a joint determination of the temperature of the ocean's surface and the optical thickness of the atmosphere, making it possible to distinguish the contributions of the sensed surface and of the atmosphere to upward radiation. The procedure is based on measuring the angular distribution of radiant intensity in the 11.1 micrometer region of the spectrum while enlisting data on t radiation's spectral

and polarization structure. Angular distributions of radiant intensity are extrapolated to a zero air mass (m = 0) for determining the temperature of the ocean's surface, and the solution obtained takes into account both the transformation of radiation in the atmosphere and the angular dependence of the ocean's emissivity. Polarization measurements of radiant intensity make it possible to take this dependence into account in greater detail and make it possible to proceed, with certain assumptions, from these measured values to radiant intensities corresponding to emissivity of the surface equal to one. The solution of the set of equations derived makes it possible to determine also the optical thickness of the atmosphere. The results are given of an experiment on 25 January 1980 on board the Cosmos-1151 satellite, in which radiometric measurements were made of radiant intensity for determining the optical thickness of the atmosphere. Variations in the sea surface's emissivity were taken into account by utilizing polarization measurements in the 11.1 micrometer region of the spectrum and spectrum measurements in the 12.9 and 18-to-19 micrometer regions. At 6.6 degrees latitude north, 35.3 degrees longitude west, with a moisture content of 3.2 grams per square centimeter and a sea surface temperature of 298.8 K, the optical thickness of the atmosphere was 0.33 and the surface's share in the upward radiation was 75 percent. The results verified the serviceability of the technique described. Figures 3; references 25: 19 Russian, 6 Western.

UDC 633.1: 629.78

Correlation Between Grain Yield and Spectral Reflectance Factors in Various Phases of Development of Barley

18660198f Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 7 Jan 87) pp 67-73

[Article by T. A. Nilson, Kh. R. Roostalu, Yu. Y. Kydar and Yu. K. Ross, Institute of Astrophysics and Aerophysics, Estonian SSR Academy of Sciences, Tartu; Estonian Agricultural Academy, Tartu]

[Abstract] The results are presented of an experimental study conducted in the Estonian SSR of the correlation between the barley yield and spectral reflectance factors measured in various phenophases. Yield governing factors that are determined by the crop's state in key phenophases can in principle be taken into account from measurements of the crop's spectral reflectance. The ability to forecast a grain yield from measurements of the optical characteristics of the crop in a certain phenophase stems from the fact that the yield is determined to a considerable degree by the crop's density characteristics in the phenophases in which these characteristics have maximum values. These density characteristics include the leaf surface index, the amount of chlorophyll per unit of area and the total absorption by the plants of photosynthetically active radiation. The significant phenophases for grain in this context are those from tillering to heading. In Estonia a considerably smaller percentage of the total variation in the yield of barley is determined by soil moisture content and air temperature after the heading phase. The potential yield can thus be predicted on the basis of the estimated density characteristic from measurements of the crop's spectral reflectance factors. Measurements were made from 1984 to 1986 in specially prepared barley plots belonging to the Estonian Agricultural Academy and consisting of limed loamy soil. The variety of barley planted was Yuliya. Nitrogen fertilizer was applied at four different rates. Spectral reflectance factors were measured by means of a 4-channel field photometer designed by Akho and Sulev (1980) with interference light filter transmission maxima at 482, 553(10), 647(10) and 780(20) nm. Reflectance factors were measured once or twice in each phenophase on the same day in all plots when possible and were averaged for an area of approximately two square meters. Calculations were made of the ratio of reflectance factors in the near infrared and red regions of the spectrum, the normalized difference vegetation index, the greenness index, the soil reflectance index and the perpendicular vegetation index. A highly linear correlation was found between grain yield and spectral reflectance factors in two of the years, while in the third year the correlation was nonlinear. This same year was less favorable for barley. The overall conclusion is that spectral measurements about two months before harvesting may help to estimate the potential barley yield. Figures 5; tables 2; references 8: 3 Russian, 5 Western.

UDC 528.831: 528.855(479.24)

Spectral Contrasts of Certain Soils From Data of Gyunesh-84 Experiment

18660198g Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 16 Jul 86) pp 74-80

[Article by Sh. A. Akhmedov, F. M. Gadzhi-Zade, M. N. Yelichev and E. A. Mamedov, Scientific Production Association for Space Research, Baku]

[Abstract] Selecting sections of the electromagnetic wave spectrum having the greatest information content taking into account the spectral contrasts of various objects against the background of the Earth's surface is important from the viewpoint of improving the effectiveness of remote methods of studying the Earth's surface. Data are presented on the spectral contrasts of 22 soil patterns studied during the Gyunesh-84 international experiment conducted from 19 August through 7 September 1984 at the Sheki-Zakataly testing grounds of the Scientific Production Association for Space Research, Azerbaijan SSR Academy of Sciences. The unique closed geosystem of saline and solonchak soils of the Ajinour Steppe was studied in particular. Ground measurements were made by means of the Bulgarian ISOKh-020 and USSR PPS spectrometers. The ISOKh-020 measures with precision of 0.1 percent and its sensitivity can be adjusted smoothly and by steps over a wide range. The PPS

portable field spectrometer, developed by the Azerbaijan scientific production association, can measure in 22 spectrum intervals 10 to 12 nm wide, has a 12-degree field of view and measures with 0.2-percent precision. Measurements were made from a height of 150 cm from 1100 to 1300 and from 1400 to 1600 hours under a cloudless, clear sky. The soil's temperature and humidity varied over the range of 21.5 to 26.0 degrees Celsius and 17 to 30 percent, respectively. The air temperature varied from 29.5 to 32.0 degrees Celsius with a wind velocity of 5 m/s and relative humidity of 38 percent. Spectral contrasts were calculated for wavelengths of 400 to 1025 nm every 20 to 25 nm. The calculated contrasts for various object-background pairs were divided into groups of contrasts close in value and the mean values of contrasts were classified. The classification system is discussed in detail, and the 22 object-background pairs are listed. The 450 to 550 nm, 600 to 650 nm and 900 to 1025 nm bands of the spectrum were rated as the most informative based on spectral contrasts and were therefore recommended for making images of the varieties of soil being studied. Figures 3; tables 3; references 4 Russian.

UDC 528.8.044

Airborne Laser Spectrofluorometer for Remote Sensing of Earth's Surface

18660198h Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 1 Dec 86) pp 81-85

[Article by V. M. Avetisyan, V. G. Atanesyan, A. A. Melik-Sarkisyan, A. A. Nazaryan, R. G. Oganesyan, V. A. Sulkhanyan, A. A. Frangyan and G. O. Sharkhatunyan, Scientific Research Institute of Physics of Condensed Media, Yerevan State University, Yerevan]

[Abstract] A description is given of an airborne spectrofluorometer developed for the purpose of obtaining the full backscatter radiation spectra of various natural objects that can be excited by a single laser pulse when necessary. A sensing diagram is presented for use of the instrument for remote sensing from an Mi-8 helicopter, as well as the spectrofluorometer's optical circuits for its installation in an airplane and helicopter, and a block diagram of the instrument. The laser's radiation is directed at a frequency of up to 20 Hz via a set of mirrors onto the surface being studied. The pulse energy is 25 mJ at 532 nm, 6 mJ at 335 nm and 3 mJ at 337 nm. The backscatter radiation is received by a telescope having a linear aperture of 260 mm via a mirror, with the laser and telescope forming a coaxial system. There is a collimator in the telescope's exit with the slit of a polychromator at the collimator's focal point. The part of the radiation from the collimator's exit responsible for the signal at the laser's wavelength reflected from the object's surface is deflected by means of a plate and is fed via a filter to a timing multiplier phototube. The polychromator contains a 300 line/mm diffraction grating. An optical fiber distribution frame having a rectangular inlet cross section is placed in the polychromator's exit. Every 2 mm of this frame's width are led by means of an individual optical fiber cable to one phototube of a block of multiplier phototubes. The pulses from this block are fed via a delay unit and amplifier to an analog-digital converter. All this equipment is connected via a CAMAC line to an Elektronika-60 microcomputer equipped with alphanumeric and graphic display units, printers and a magnetic tape storage. The full backscatter radiation spectra, the flight altitude, data on the scanner's position and the time of day can be recorded in the computer's memory. This spectrofluorometer makes it possible to obtain the full fluorescence spectra of objects, measure the concentration of fluorescent molecules and its distribution by depth, identify molecules and corresponding natural objects, and to measure depth in shallow water. Presently an excimer laser is being added to this spectrofluorometer to increase both its effective range and the reliability of the information obtained. Figures 3; tables 1; references 7: 4 Russian, 3 Western.

UDC 681.3: 528.72

Software Package for Clustering of Multiband Data

18660198i Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 2 Apr 87) pp 86-94

[Article by V. V. Asmus, V. Valas, A. B. Karasev, L. Kechkemeti and Yu. G. Spiridonov, State Scientific Research Center for Studying Natural Resources, Moscow; Central Meteorological Institute, Budapest]

[Abstract] A description is given of a cluster analysis module that is a component of an adaptive automated system for pattern recognition in multiband aerospace images. The subsystem developed consists of four principal modules: 1) For the correction of "hybrid" points whose reflectances are produced because several classes of objects fall within the instrument's field of view or are distorted by the background. 2) For data compression or coarse clustering, i.e., isolating homogeneous subsets or constructing a mutidimensional histogram. 3) For clustering per se, i.e., the iteration method, hierarchical grouping and modal analysis. 4) For cluster map compilation (coloring). The compression module is of fundamental importance because it makes it possible to surmount the limitations relating to the use of a number of efficient clustering procedures and associated with large numbers of and the multidimensionality of remote measurements. The processing procedure is [illegible] sequence of algorithms. The data necessary for the operation of the next module are formed in each module. Several algorithms of a single module can operate sequentially. When the subsystem processes an image containing one million multiband vectors, after the step of the isolation of homogeneous subsets the number of data is reduced to 1000 to 10,000 vectors. Then these vectors are processed by the iterational clustering algorithm with the modes of a multidimensional histogram used as the initial centers.

The approximately 100 centers obtained are then subjected to hierarchical analysis where the final separation is performed. The software is written chiefly in FORTRAN-IV for YeS [Unified Series] computers and consists of about 11,000 commands. The software imposes practically no restrictions on the size of the images that can be processed. The cluster analysis algorithms employed implement various approaches to the clustering task and make possible total coverage of the subject area by means of combinations of different methods. The two-stage cluster analysis system consisting of a data compression stage and clustering per se represents a new feature of a clustering package, as does also the hydbid point correction module. An "optimal marking" procedure is also included. Based on an error minimization criterion, it sets up a correspondence between thematic and spectral classes isolated as the result of clustering. Figures 1; references 14: 9 Russian, 5 Western.

UDC 528.72: 681.3

Analysis and Recognition of Images in Radon Space

18660198j Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 23 Jun 86) pp 95-100

[Article by I. I. Bakhshiyev, V. A. Petrosyan, A. Yu. Kambarov and T. R. Gadzhiyeva, Scientific Production Association for Space Research, Baku]

[Abstract] Theoretical grounds are given for the method making it possible to process images in Radon space. Radon's transform serves the function of reducing the dimensionality of the task. This in turn makes it possible to conduct a two-dimensional spectrum analysis of images by the one-dimensional processing of signals and considerably simplifies the hardware required. In the designing of automatic and interactive systems for the thematic processing and recognition of images the important task arises of choosing primary and informative characteristics. This problem is also discussed. An important step of this approach to the analysis and recognition of images is that of forming a data subsystem, i.e., a subsystem of primary characteristics, based on the spectral characteristics of the images studied. The problem is discussed of the choice of primary and informative characteristics for solving the problem of recognizing and classifying random signals. The problem is reduced to representation of the signals to be analyzed as a linear combination of simpler functions forming an orthonormal base. The task of designing a recognition system intended for the automatic classification of the realizations presented can be reduced to constructing a small number of informative characteristics and a decision rule. A two-step process is employed for reducing the dimensionality of the space of characteristics. Fairly simple primary characteristics are computed in the first step and informative characteristics are determined in the second. The statistical decision making method is used to choose the base on which the primary characteristics are computed. It is shown that, from the viewpoint of the minimum mean risk criterion, it is best to form on a base of Haar functions primary characteristics for the classes of signals having the correlation functions defined and a priori unknown probability characteristics. An analysis of models of various classes of stationary processes has shown that the mean risk on a Haar base is 6- to 7-fold lower than on a Fourier base and practically does not depend on the probability distribution for the presentation of each class of realizations. According to the same mean risk criterion, informative characteristics are best computed in terms of Karhunen-Loewe functions. Figures 2; references 6: 5 Russian, 1 Western.

UDC 629.783: 778.39

Methods of Eliminating Conflicts Between Functioning Modes of Earth Resources Satellites When Compiling Operating Schedules

18660198k Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 88 (manuscript received 17 Nov 86, after correction 29 Jul 87) pp 107-116

[Article by G. P. Anshakov, A. V. Sollogub and D. G. Bundov]

[Abstract] Conflicts often arise between the functioning modes of Earth resource satellites when drawing up operating schedules for them. By a conflict within a certain time frame is meant the fact that several modes seek execution. Conflicts are eliminated by assigning one mode for execution while blocking the execution of others. The resolution of conflicts is also important from the viewpoint of improving the performance of satellites. It is demonstrated here that the use of linear programming methods for solving conflict problems of this type is limited for purposes of longterm planning because of the great computational difficulties that arise. It is necessary to develop methods based on dynamic programming and Pontryagin's maximum principle. The application of dynamic programming is discussed for solving the problem of writing an operating program for resolving the conflicts that arise in gathering data and transmitting data to the receiving station on the assumption that both operations cannot be performed simultaneously. The data are gathered and stored in an on-board memory of limited capacity. The time periods for gathering and transmitting data sometimes overlap. The problem is to schedule the operating modes so that the satellite's performance will be maximized over time period T. Performance is rated in terms of the amount of information transmitted to the receiving station during time T. The optimal control vector for the operation of the satellite's equipment is derived by dynamic programming. The same problem is solved by using Pontryagin's maximum principle. Both approaches are used to develop trade-off methods of achieving conflict-free performance. The algorithm for solving the problem by dynamic programming is simpler to implement than the algorithm employing Pontryagin's maximum principle. Figures 3; tables 5; references 2 Russian.

Justification for Manned Mars Mission, Technical Options for Flight

18660184 Moscow PRAVDA in Russian 24 May 88 p 3

[Article by Academician V. Glushko, USSR Academy of Sciences Corresponding Member Yu. Semenov, and Doctor of Technical Sciences L. Gorshkov under the rubric "Fantasy on the Drawing Board"; "The Road to Mars"; first six paragraphs appear in italic in source, as introduction to article]]

[Text] The short letter by Professor F. Volkov, "Do We Need to Fly to Mars?" (Pravda, 10 February 1988) evoked a stormy reaction. Responses have come by the dozens. From Moscow, Odessa, Voronezh, Sverdlovsk, Minsk, Tbilisi, Kherson, Ryazan, and the remote Krasnoyarsk Kray. People are taking turns being "for" or "against."

"It is naive to think that we should successfully overcome our problems on Earth today and only then venture to Mars and to other planets," writes S. Shardyko, research associate at the Institute of Thermophysics of the Ural Division of the USSR Academy of Sciences-."That is an illusion, because solving certain problems gives rise to others that are more complex and more threatening. Solving global problems requires of mankind space power, and it would be unreasonable, to say the least, to postpone indefinitely the attaining of that power."

The citizens of the Earth, people of many earthly professions, are upset. But what about the specialists? And the leaders of space science? How do they feel? Or are they indifferent, looking upon the project as Utopian in our age? As it turns out, no, they're not. This article addresses the fact that leading scientists in the field of cosmonautics are seriously concerned with the concreteness of this project. And wasn't F. Tsander, the wise companion of the young S. Korolev, in earnest when he began every working day in the basement of Reactive Propulsion Study Group [GIRD] with the exclamation, " Onward, to Mars!"

And there is one more important note from S. Shardyko's letter:

"The problem, obviously, is not in clarifying how many are 'for' and how many are 'against' this or that space program, but in a wider and freer access for the scientific and technical community to the results of space research and to space equipment and technology. The solution lies in the democratization of the historically inevitable process of space expansion."

In a conversation with the publishers of the Washington Post and Newsweek, M. S. Gorbachev said: "I will propose to President Reagan collaboration in setting up a joint flight to Mars....That would be worthy of both the American and the Soviet people."

Since ancient times, the interest in Mars has been associated with a dream of encountering intelligent life. Today, we can't expect that within the boundaries of our solar system.

Nevertheless, Mars rivets our attention because of a natural desire to take a peek at our neighboring planet, a world completely unfamiliar to us and, probably, a world unlike our own. We rightfully count on finding traces of the history of Mars and of interesting natural formations. Many of the discoveries that await us on Mars will probably bear a direct relationship to discoveries on our planet.

You sometimes hear the question, Do we need to fly to Mars? Some feel that we have so many pressing tasks that manned flight to Mars can wait. But if we had judged that to be true, there wouldn't have been the first satellite or the flight of Yuriy Gagarin. None of cosmonautics would have come about. Why, when it started, no one thought that space flight would begin to have direct benefits so quickly.

All this, it would seem, is common knowledge. And still we hear: Do we need to arrange a flight to Mars today? Couldn't we, indeed, postpone it until we solve all our pressing problems? We must admit here that, in all probability, we will always have pressing problems, and that approach could actually stop the development of science and technology.

What kinds of technical possibilities do we have at our disposal here? What kind of spacecraft could deliver man from planet to planet?

Figure 1 presents a diagram of one version of such a craft. An interplanetary vessel consists of three basic components: a propulsion unit for flight along interplanetary trajectories; living quarters, where the crew works during the course of the entire flight and which include equipment for keeping the crew active as well as the primary flight-control gear; and the lander, in which the crew descends to the surface of Mars and returns to a Martian satellite orbit, to the interplanetary craft.

The interplanetary craft is assembled in near-Earth orbit from individual units that are delivered from Earth by boosters like the Energiya boster. After the serviceability of all the systems and assemblies of the craft is checked, the expedition heads for Mars. The crew (4-6 people) may include representatives of the various countries that participated in preparing the expedition.

Figure 2 shows a diagram of the flight of the craft. Using its propulsion unit, the interplanetary craft races from its near-Earth orbi' to a near-sun orbit, crossing the orbit of Mars. It takes several months to fly to Mars. At the point at which the flight trajectory crosses the orbit of Mars, the craft begins orbiting Mars and becomes an artificial satellite of the planet. Since landing the entire interplanetary craft on the Martian surface would be a rather

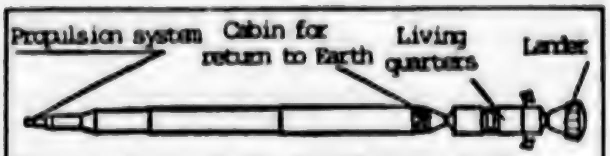

Figure 1. Design of the interplanetary craft

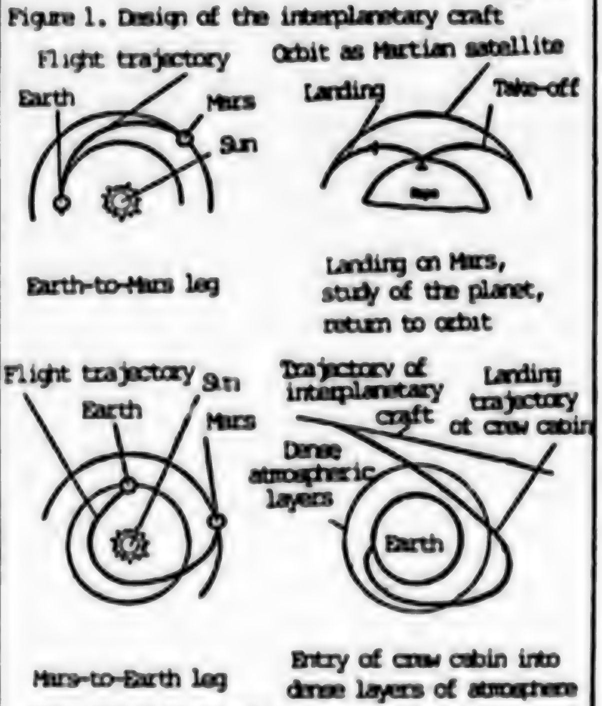

Figure 2. Flight configurations to Mars

complex task and would require a large amount of fuel, a comparatively small lander, with the crew or part of it, will make the descent. After completing its work on the surface, the crew will launch itself into orbit, transfer to the interplanetary craft, and return to Earth. The diagram shows a version in which, over the course of the flight to Mars and back to Earth, nearly one and a half revolutions around the sun are made, which means the expedition lasts about one and a half years.

The overall duration of the flight could be shortened, but the required fuel reserves would be markedly greater and, consequently, the mass and size of the craft would grow, along with the problems associated with developing such a vessel.

For increased safety, the flight to Mars could be made with two interplanetary craft traveling at the same time. The crew of each could, if necessary, come to the aid of the other.

One of the principal questions centers on the choice of the propulsion unit that would be used to accelerate the craft from its Earth orbit to Mars, transfer it to a Martian satellite orbit, and then remove it from that orbit and send it back to Earth.

We could, for these purposes, use the rather well-refined liquid-fuel reaction-propulsion systems that use the chemical energy of rocket fuel consisting of, for example, two components—hydrogen and oxygen. That is the most efficient fuel in use today for such systems (it is used, in particular, in the new Soviet booster rocket, Energiya). Developing such systems for the flight to Mars does not, at first glance, present serious problems. But since the amount of energy needed for the Martian expedition is rather high (the Mars-bound craft is considerably heavier than the automatic interplanetary probes that have already flown), the fuel reserves for the propulsion systems would be large. And assembling such a craft in near-Earth orbit would be quite complicated. Suffice it to say that the initial mass of such a vessel would be greater than 2,500 tons.

Naturally, the more efficient power sources are used for flights along interplanetary trajectories—nuclear sources. Nuclear reactors serve as a heat source that, after warming a gas, forces it through the nozzles of the engine and creates a reactive thrust. The required fuel reserves—or, as they say in rocket technology, the "working fluid" (the gas that is ejected from the propulsion nozzles)—are substantially smaller than those of liquid-fuel propulsion systems (by a factor of 2 or 3). The initial mass of such a craft would be about 800 tons.

A still more efficient system is the nuclear electroreaction unit. In this system the thermal energy of the reactor is converted into electrical energy, and the working fluid is accelerated by an electrical field to create the necessary thrust. For a given task, these units require less working fluid than the fuel required for liquid-fuel units (an amount 15-20 times smaller). The initial mass for this kind of craft could be as small as 450 tons.

Let's take a look at the features of the other components of the interplanetary craft. The living quarters are the central component. They consist of a hermetically sealed compartment or comparments than contain the crew cabins and the equipment racks.

The crew must have oxygen for breathing, water, food, and some means of removing waste. The development of these systems is already at a level that completely satisfies the requirements of interplanetary flight.

The living quarters contain equipment for maintaining radio communications with Earth. The craft must have the equipment necessary for autonomous navigation and flight control. Which means that the flight can be carried out by the crew itself. Comfortable temperature levels are maintained in the living compartment by an air-conditioning system similar to those used aboard orbital stations. Either a nuclear reactor or solar batteries can serve as the source of electrical power for the systems in the living quarters.

To reduce radiation exposure during the flight, equipment and system assemblies are located along the hermetic shell of the living quarters. For additional radiation safety, the living quarters must have an area that provides a higher level of protection from cosmic radiation, i.e., a special radiation shelter for the crew in the event of, say, solar flares. On orbital stations, the crew is protected from such flares by the Earth's powerful magnetic field. On interplanetary flights, however, there is no such protection, and additional measures must be taken to protect the crew. It is not at all necessary that the crew remain in the shelter during the entire time of a solar flare. It is important that it spent the bulk of its time there, including sleeping hours, and the total dose of radiation will not be hazardous for health.

Another important safety question involving the living quarters centers on protection from meteor fragments. In space flight, including that in near-Earth orbit, encountering meteor fragments is highly probable. The most effective means of protection is a special shield that envelops the shell of the living quarters. When a meteor fragment is encountered, the shield is pierced, but only a stream of gas—which the fragment and the shield material become when they collide—reaches the shell. The Salyut and Mir orbital stations, by the way, were designed in this manner. The chances of encountering a meteor whose mass would have enough energy to pierce both the shield and the shell are extremely slim, but such an event could be taken care of by dividing the living quarters into separate compartments, and the crew could have all the necessary equipment for repairing the external shell if the seal were ruptured.

The next component of the interplanetary craft is the lander. It has an appropriate aerodynamic shape, because the landing is performed in the atmosphere. Since the atmosphere at the Martian surface is several times less dense than that of Earth, a liquid-fuel propulsion unit is used for the landing. The lander includes a take-off rocket, on which the crew, in the cabin, returns to the interplanetary craft.

Different flight variations can be used for the return to Earth: using engines to brake the craft near Earth and entering a near-Earth orbit (this requires substantial additional amounts of fuel) or using the Earth's atmosphere to brake and entering it at escape velocity. In the latter instance, the Martian craft must have a special cabin (see Figure 1) into which the crew transfers itself just before reaching Earth. This cabin separates from the Martian craft and enters the dense layers of the atmosphere on its own. Subsequent descent is with parachutes.

In choosing a return configuration, one must also think of protecting the Earth from dangerous biological Martian forms, the possibility of which cannot yet be discounted entirely. After the return to Earth, the crews and anything that came in contact with the Martian atmosphere must be thoroughly examined. A long quarantine will be necessary. If the return is to Earth orbit, the quarantine can be carried out on an orbital station. The advantage of that is the adequate, natural isolation from Earth; the disadvantage, the limited possibilities for medical and biological studies. A quarantine that follows a direct landing on Earth at escape velocity can be carried out in a special, insulated structure, where the crew can exit the craft only after it has been brought to this "hangar." The medical and biological quarantine studies can be more thorough on the ground than in an orbital station.

Now let's take a look at just how prepared world space technology is to organize the first interplanetary mission. What problems must be solved before a small group of Earth's representatives set foot on the surface of another planet?

One may consider the assembly of the craft from individual components in near-Earth orbit to have been worked out at this point. A great deal of experience has been garnered in this area by the USSR, whose system of automatic assembly in space has been in use for more than 20 years. Manual docking, used both by the USSR and the United States, also has applications in the Martian expedition.

Both the USSR and the United States have experience in measuring the parameters of interplanetary trajectories and in flight control. Unmanned craft have been launched to the closest planets—Mars and Venus—as well as to remote planets of the solar system.

The flights of orbital stations (Salyut, Skylab, and Mir) have made it possible to develop means for man to spend lengthy periods in space. An important part of this is developing reliable gear. Counting on the Earth for help here will be difficult, so all the equipment, including the repair equipment, must be aboard the craft.

As far as the lander goes, similar problems have already been solved. The United States has a great deal of experience in landing crews on the surface of the Moon and bringing them back up: in 1969-72, American astronauts in Apollo landers made six landings and take-offs on the Moon. Unmanned Soviet craft have landed on the Moon and taken off. Unmanned Soviet and US spacecraft have landed on planets (Mars and Venus).

Liquid-fuel propulsion systems are widely used in space technology. The USSR and the US are developing promising propulsion units that use nuclear energy: nuclear electro-reaction units, for example, and nuclear units that use direct conversion of heat to a propulsion stream.

Many countries of the world that have participated in space flight have gathered a good deal of experience in designing and developing various equipment and gear that can be used aboard an interplanetary craft.

The question also arises, Can a crew work for such a lengthy period of time in weightlessness? For many years now, the USSR has been doing work in this area. The road has been long and bumpy. There have been moments when it seemed that weightlessness was an insurmountable barrier to lengthy space flights. After the 18-day flight of A. Nikolayev and V. Sevastyanov, for example, readapting to Earth was so difficult for the crew that increasing the duration of flights beyond that length of time was a problem. But means for keeping the crew in good physical shape were developed that exercised the muscular system and cardiovascular system. The work continued. The length of the flights was gradually increased over a period of several years among the crews of orbital stations, and, in December of last year, Cosmonaut Yu. Romaneko, who holds the record for time spent in weightlessness, returned to Earth after a 326-day flight—and he returned in excellent physical condition. The success of the lengthy flights is one of the results of a special program of physical training aboard the stations. Thus, we have every reason to be optimistic about the possibility of long-term space flight.

Of course, we must not simplify the problem: space specialists must still solve many technical and medical problems in organizing such a grandiose event as a flight to Mars.

The flight to the planet nearest us is on today's agenda. It is not only a scientific and technical issue; it is also an issue associated with the progress of civilization on Earth.

U.S. Company To Fly Biocrystal Experiment on "MIR" Station

18660223 Moscow SOVETSKAYA ROSSIYA in Russian 12 Apr 88 p 3

[Article by Yu. Subbotin]

[Excerpt] For the first time, the U.S. Government has authorized a private American company to conduct scientific research on board a Soviet space station. A commercial agreement has been reached between this firm, "Payload Systems Incorporated," and the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos). This agreement calls for conducting a series of six experiments, in the course of which an American unit for growing biocrystals will be delivered to the "Mir" station by a "Progress" transport spaceship. This unit will operate on the station in conditions of prolonged weightlessness. Soviet cosmonauts will return it to Earth when the next experiment is completed. The product which is obtained can ultimately be utilized for development of new drugs.

"The time that American reusable spaceships can stay in orbit is in fact limited to 7-10 days," asserted V. Ye. Lukoyanov, senior expert o. Glavkosmos. "The technical possibility of a month-long flight has never been demonstrated as yet. In our country, reckoning is done in terms of years."

Anthony Arrot, director of the research department of "Payload Systems" and one of the company's founders, thinks that long-term experiments on board the Soviet station "Mir" will look attractive even after flights of American reusable spaceships resume, for precisely this reason.

"We guarantee the absolute inviolability of the American equipment," emphasized V. Ye. Lukoyanov. "In line with our agreement, the composition of the biological material will be known only by the firm that prepares it and the company that will submit an evaluation of the biological safety of this material to us. The latter will be a neutral firm—neither a Soviet nor an American one. "Payload" may also be among the firms that know these secrets, although this company is essentially a consulting and mediating organization whose main function is organizational. Upon completion of the experiment, which will require minimal attention from our cosmonauts, we shall merely turn the unit over to American specialists."

FTD/SNAP

Austria Approves Proposal for Space Mission With USSR

18660224 Moscow IZVESTIYA in Russian 7 Apr 88 p 4

[TASS Report]

[Text] Vienna, 6 April. A decision calling for an Austrian cosmonaut to take part in a mission on the Soviet orbiting station "Mir" was adopted at a meeting of the Austrian Council of Ministers which has taken place. The purpose of this mission will be to conduct joint experiments with Soviet scientists. The decision was adopted following a proposal made during the official visit to Austria of N. I. Ryzhkov, chairman of the USSR Council of Ministers, in July of last year. The possibility of conducting a joint mission was the topic of this proposal.

Otto Zellhofer, a senior associate of the Austrian Ministry of Science and Research, noted in a conversation with journalists that the government's decision has become a signal for the official beginning of preparations for this mission, including not only selection of a cosmonaut candidate but also determination of a program of experiments which can be performed on board the station. The candidate will subsequently have to complete a 2-year program of training in the Soviet Union. Zellhofer mentioned that the ministry had received many requests for participation in such a mission even before the official decision was adopted.

FTD/SNAP

TASS Statement on "Cosmos-1900" Nuclear Powered Satellite

18660225 Moscow PRAVDA in Russian 14 May 88 p 6

[Text] TASS announcement. An artificial Earth satellite, "Cosmos-1900," with an onboard nuclear power plant was launched from the Soviet Union on 12 December 1987. According to data from competent Soviet organizations, radio communication with this satellite was disrupted in April of 1988. The satellite is continuing its oriented flight, and its main auxiliary systems are operating in line with a program. The satellite's flight in orbit will be in progress until August-September 1988, after which it will cease to exist. On board the satellite "Cosmos-1900" are systems which will ensure radiation safety upon the completion of its flight.

The flight of the satellite "Cosmos-1900" is under constant observation.

FTD/SNAP

U.S.-USSR Agreements on Solar-Terrestrial Physics, Space Astronomy

18660226 Moscow PRAVDA in Russian 4 May 88 p 5

[TASS Report]

[Excerpt] Washington, 3 May. On Monday, two important documents were signed in Washington by representatives of the USSR Academy of Sciences' Institute of Space Research and the U.S. National Aeronautics and Space Administration. The purpose of these agreements is to broaden American-Soviet cooperation in research of space for peaceful purposes. Memoranda were signed in regard to Soviet-American joint working groups on sun-Earth physics and space astronomy and astrophysics. Meetings of these working groups took place.

FTD/SNAP

Space-Based Astronomy Said To Be Neglected Area

18660227 Moscow LITERATURNAYA GAZETA in Russian No 18, 4 May 88 p 11

[Article by Grigor A. Gurzadyan, member of Armenian Academy of Sciences, head of Byurakan Observatory's laboratory of extra-atmospheric astronomy, head of a chair of instruction at Yerevan Polytechnical Institute]

[Abstract] The article compares and contrasts the status of extra-terrestrial astronomy and astrophysics in the USSR and abroad. An editorial preface to the article identifies the author as scientific director of experiments with the orbiting astrophysical observatories "Orion-1" and "Orion-2."

The author complains that space astrophysics has been unjustifiably neglected by both scientists and information media as compared with astronomy using equipment on the ground. He notes that the USSR still has no institute of space astronomy, or astrophysical observatory-satellites comparable to the "Copernicus," "IUE" and "IRAS" sapcecraft of other countries, for example. The successful flight of "Orion-2" in 1973 was not followed by further work in this direction, while not a single scientific article or other publication on results achieved with the space observatory "Astron" has appeared since it was launched 5 years ago. Few other space observatories are currently in operation, and most of them are on manned orbiting stations of the "Salyut" and "Mir" types. Work in the field of space astronomy is being done only at the USSR Academy of Sciences' Institute of Space Research, and it specializes chiefly in planetary astronomy. The author disparages the departments of extra-atmospheric astronomy which some observatories have created, pointing out that each of these divisions has only two or three astronomers on its staff and no planning-and-design department or experimental facilities at all.

For space astronomy to advance, it must receive some of the money which is now being allocated for construction and expansion of terrestrial facilities, and the USSR Academy of Sciences' present system for selecting, planning and coordinating space-astronomy experiments must be radically overhauled, the author contends. Development of high-precision unmanned space observatories intended for astronomical purposes exclusively is mentioned as a direction which merits particular attention. The author suggests that the country needs not only an academy institute or laboratory but also a special design bureau specializing in space-astronomy R&D. This bureau would possess strong resources and be affiliated with a suitable ministry.

FTD/SNAP

Sagdeyev Criticizes Organization of Soviet Science, Emphasis on Manned Space Programs

18660228 Moscow IZVESTIYA in Russian 28 Apr 88 p 3

[Article by R. Sagdeyev, academician]

[Abstract] The lengthy article calls attention to administrative and planning problems which the author says are slowing the advancement of basic research.

Criticism is directed in particular at research planning practices, rules governing the tenure of science officials, and the oversized and unwieldy staffs of many research institutes. Large numbers of parascientific personnel have been added to the staffs of institutes in recent years, the author explains. This multiplies the institutes' administrative problems and adds to their financial burdens. Scientists who hold management positions in

these institutes are often so preoccupied with organizational and business matters that they have little time to spare for basic research and training of young scientists. This has adversely affected creative interaction among scientists, expert evaluation of ideas, and upward mobility of younger scientists, according to the author.

The author suggests that research planning ought to be restructured so that basic science receives higher priority for advancement and allocation of resources. In many cases, academy science is at a disadvantage compared with industries which have superior production capacities and more advanced technology at their disposal, he explains. Moreover, industry has been more effective than science in promoting its own special interests and pet projects. In the field of space technology, for example, development and introduction of manned spacecraft has received first priority, although practically all of the main results of space research in fields other than space medicine have been achieved by means of unmanned spacecraft, it is claimed.

"While the great space powers vie with each other in attempting to place huge structures (orbiting stations populated by representatives of the human race) into orbit, small Japanese robots are conquering the commercial market on Earth," the author points out. "Hard radiation from the supernova that flared up last year was discovered with the aid of the international observatory of the module 'Kvant' on the 'Mir' station. This would appear to be a weighty argument in the controversy. But only, of course, if we ignore the fact that we had to share the honor of being the first to discover the supernova's x-radiation with the observatory on board a miniature unmanned Japanese satellite called 'Ginga'."

The author also derides the quality and quantity of computer technology at the disposal of academy research personnel and engineers, and he suggests that amateur designing and small-scale production of computers might ease the shortage. "If we had not promptly begun developing special 'homemade' computers at the Institute of Space Research in processing results of encounters of the 'Vega' spacecraft with Halley's Comet, we could not have kept up with computer instruction of the European comet probe 'Giotto' which flew by the comet only a few days later," he recalled.

FTD/SNAP

USSR International Projects in Space Research

18660097 Moscow NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA KOSMONAVTIKA, ASTRONOMIYA, Dec 87 pp 38-57

[Article by S. A. Nikitin: "International Cooperation of the USSR in Space"]

[Text] In 1987 international cooperation of the Soviet Union in the exploration and use of space for peaceful purposes developed successfully with nine socialist countries (NRB [People's Republic of Bulgaria], VNR [Hungarian People's Republic], SRV [Socialist Republic of Vietnam], GDR [German Democratic Republic], Republic of Cuba, MNR [Mongolian People's Republic], PNR [Polish People's Republic], SRR [Socialist Republic of Romania] and the CSSR [Czechoslovakian Soviet Socialist Republic]) within the framework of the Interkosmos Multilateral Program, and on a bilateral basis with Austria, Great Britain, India, France, the FRG, the U.S., Sweden and other countries, as well as with the European Space Agency. Through the Intercosmos Program, joint efforts were conducted in the field of space physics, including space materials technology, in the field of space meteorology, communications, space biology and medicine, as well as remote sensing of the Earth to study its natural resources. Joint efforts in space on a bilateral basis with the above listed countries encompassed virtually all the main fields of astronautics.

In 1987 the main events in the international cooperation of the USSR in space were: the launch of the Kvant international astrophysics observatory; the flight of the Soviet-Syrian international crew; international experiments carried out on the Mir orbital station by members of its main crew, cosmonauts Yu. V. Romanenko and A. I. Laveykin; and the flight of the latest Cosmos international biosatellite. This year marked the anniversary of the Intercosmos program, and new agreements were signed on cooperation in space between the USSR and the U. S., and the USSR and Great Britain. On 2-4 October 1987 an international forum was held in Moscow on the topic "Cooperation in Space in the Name of Peace on Earth." Approximately 900 Soviet and foreign scientists and specialists in the field of space research took part in the work of this forum.

New international space crews are being trained at the Yu. A. Gagarin Cosmonaut Training Center near Moscow. A second Soviet-Bulgarian manned flight (cosmonaut candidates from the NRB are A. Aleksandrov and K. Stoyanov) is planned for 1988 on a Soviet spaceship and orbital station. French astronaut (J.-L. Chretien) and candidate astronaut (M. Tognini) are also training at the Zvezdnyy facility, preparing for a second Soviet-French manned flight. One of them will join the Soviet-French crew that in 1988 will accomplish a flight on a Soviet spaceship and orbital station. The planned duration of this flight is approximately 30 days, and it is anticipated that a French astronaut will accomplish a space walk.

An understanding has been achieved about carrying out a Soviet-Afghan space flight in the first half of 1989. During talks between N. I. Ryzhkov, chairman of the USSR Council of Ministers, and F. Vranitzky, federal chancellor of Austria, it was reported that, taking into account the desire expressed by the Austrian side, the Soviet Union was examining the question of a possible joint flight of Soviet and Austrian astronauts. The flight of this international crew can be carried out in the early 1990's (considering preparation time).

On 31 March 1987 USSR Minister of Foreign Affairs E. A. Shevardnadze and British Secretary of State for Foreign and Commonwealth Affairs Sir Geoffrey Howe signed in Moscow an "Agreement Between the Government of the Union of Soviet Socialist Republics and the Government of the United Kingdom of Great Britain and Northern Ireland About Cooperation in the Field of the Study, Exploration and Use of Space for Peaceful Purposes." Cooperation within the framework of this agreement will encompass such scientific fields of space research as solar-earth physics, planetology, high energy astrophysics (including astronomical research in the x-ray and far ultra-violet bands), submillimeter and infrared astronomy, radio astronomy, materials technology, space biology and medicine, as well as other fields that may be mutually agreed between the countries from time to time.

Joint measures within the framework of this agreement, signed for 10 years, but remaining in effect thereafter unless one of the parties informs the other that the agreement is no longer in effect, will be implemented in the following forms: exchange of delegations of scientists and other specialists, and participation in joint research and planning efforts determined by scientific and other research organizations; sharing of experience, scientific information and literature; cooperation in implementing joint projects for the development, creation and launch of apparatus; holding of joint symposia and other measures for mutual coordination of the two parties.

On 15 April 1987, USSR Minister of Foreign Affairs E. A. Shevardnadze and U. S. Secretary of State George Shultz signed an "Agreement Between the USSR and U. S. on Cooperation in the Exploration and Use of Space for Peaceful Purposes." The term of the agreement was five years, and it can be extended for a new five-year period by an exchange of notes between the parties.

This agreement provides for cooperation in such fields of space science as study of the Solar System, space astronomy and astrophysics, Earth sciences, physics of solar-terrestrial relationships, and space biology and medicine. Cooperation in these fields will be carried out by mutual exchange of scientific information and delegations; organization of meetings of scientists and specialists; exchange of scientific apparatus, and in other ways by mutual agreement. Practical implementation of joint efforts will be accomplished through mixed working groups, organized in each of the above enumerated fields.

The mixed working groups will begin their activity with projects, a listing of which has been agreed upon by the parties and placed in an appendix to the agreement. This listing includes coordination of the Phobos, Vesta and Mars-Observer Projects, and sharing of scientific data on the results; joint research to determine the most promising places for a Mars landing; sharing of scientific data on study of the surface of Venus; projects in the fields of radio astronomy, space gamma, x-ray and submillimeter astronomy; coordination of observations on projects for the study of physics of solar-Earth relationships and sharing of corresponding scientific information; coordination of efforts for the study of global environmental changes; cooperation in the program of Cosmos series biosatellites; and sharing of biomedical information on USSR and U. S. manned flights.

Anniversary of the Intercosmos Program. In April 1987 the Intercosmos Program was 20 years old. This program was approved in April 1967 in Moscow at a conference of experts on questions of cooperation in space from nine socialist countries: NRB, VNR, GDR, Republic of Cuba, MNR, PNR, SRR, USSR and CSSR. On 13 July 1976 representatives of the governments of these nine socialist countries participating in the Intercosmos Program signed the "Agreement on Cooperation in the Field of Exploration and Use of Space for Peaceful Purposes." This agreement consolidated the experience acquired in joint efforts in space, and became a factor in its further development. In May 1979 the Socialist Republic of Vietnam joined the agreement, becoming the 10th country taking part in the Intercosmos Program.

Approval of the Intercosmos Program marked a qualitatively new stage in the development of cooperation among the socialist countries in space research; the transition from Earth observations, which were carried out according to a coordinated program since 1957, to closer and more effective forms of cooperation. In the 20 years of the program, 23 Intercosmos satellites, 11 Vertikal high-altitude research rockets, and a large number of meteorological rockets were launched. Instruments created by specialists from the socialist countries within the framework of the Intercosmos Program were placed aboard a number of space vehicles launched by the USSR in its national program (Cosmos, Meteor and Prognoz satellites; Venera and Vega unmanned interplanetary stations; Soyuz spacecraft; and Salyut and Mir orbital stations).

Flights of nine international crews between March 1978 and May 1981 on Soviet Soyuz spacecraft and the Salyut-6 orbital station became an important stage in the development of the Intercosmos Program. Cosmonauts who are citizens of all the cooperating socialist countries were members of these crews. The main mission of the international crews was to carry out scientific research and experiments prepared jointly by scientists and specialists of the socialist countries. More than 30 instruments and devices were especially designed and manufactured to accomplish the assigned research tasks. Through their use the international crews carried out more than 150 experiments in the field of space biology and medicine; study of the Earth's surface and atmosphere; astrophysics and study of the physical characteristics of space; and space materials technology.

Recent years have been characterized by the beginning of a new stage in the development of the Intercosmos program, the main feature of which is implementation of

large scale multi-purpose scientific and technical projects. Their implementation requires attracting scientific organizations from many countries into joint efforts; i.e., leads to the need to resort to intricate cooperation in scientific relationships. Such projects are becoming dominant in the Intercosmos program, and scientific organizations not only from the socialist, but also the capitalist countries are becoming involved in their implementation. The freshest and most vivid examples of such large-scale joint multi-purpose work are the Venus—Halley's Comet, and Phobos projects.

During 20 years of joint efforts in the Intercosmos Program results have been obtained representing a great contribution to different areas of science about space and to applied astronautics in the interests of the economy. These results have been reported systematically at COSPAR [Committee on Space Research] sessions, MAF [International Astronautics Federation] congresses, and other international symposia and conferences.

In the next few years, in accordance with jointly developed long-range plans, cooperation within the framework of the Intercosmos program will develop in all five above mentioned fields. Somewhat later we will discuss some of the projects being prepared.

The Kvant Astrophysics Module. On 31 March 1987, with the use of a Proton carrier rocket, the Soviet Union placed in near-Earth orbit a specialized Kvant astrophysics module, intended for work as part of the Mir orbital system. Docking with the Mir system was planned for 5 April.

The first attempt to dock the Kvant with the manned orbital system was unsuccessful. Up to a distance of 200 meters, rendezvous of both spacecraft took place according to the planned program, but in the final stage, due to disconnection of the guidance system of the astrophysics module, rendezvous of the apparatuses was stopped. On 9 April docking of Kvant with the orbital system was repeated. Mutual search, rendezvous, mooring and docking were carried out with the aid of automatic equipment on board the spacecraft. Kvant was docked to the station at 0436 hours Moscow time on the side of the equipment compartment. After the mechanical linking of the docking units, coupling of the space vehicles began. Analysis of information received showed that coupling of the Kvant module with the Mir station was not complete.

To carry out complete docking, on the night of 11-12 April 1987 cosmonauts Yu. V. Romanenko and A. I. Laveykin went out into open space and stayed there 3 hours and 40 minutes. Before inspection the space vehicles were separated to the maximum possible distance, by pushing out the arms of the docking unit of the module and station. This inspection showed that a foreign article that had fallen between them was preventing their complete coupling. The cosmonauts removed it, after which coupling of the space vehicles was carried out. This process was accomplished by commands from Earth and was visually monitored by the crew. As a result, the manned Mir-Kvant-Soyuz TM-2 space system, with a total weight of 51 tons and length of 35 meters, was formed in near-Earth orbit.

The Kvant is a specialized space vehicle, intended to carry out a wide variety of experiments in the field of exoatmospheric astronomy and to accomplish a number of other scientific and economic tasks. After the module was placed in near-Earth orbit by the Proton carrier rocket, its maneuvering in orbit, rendezvous and docking with the Mir station was carried out by a functional service unit, equipped with an engine unit. The initial weight of the module with its service unit was 20.6 tons. Separation of the Kvant module service unit took place after docking with the station. This took place at 0018 hours 13 April, while on the Kvant a second docking point, located on the side of the separated units and intended to receive transport craft, was released.

The main specifications of the Kvant astrophysics module are the following: weight (without the service unit; i.e., as a part of the orbital system)—11 tons; length—5.8 meters; maximum diameter—4.15 meters; payload weight—4.1 tons, including 1.5 tons of scientific instruments; weight of equipment for expanding the capabilities of the Mir station—2.6 tons.

The design of the module consists of a laboratory compartment with a connecting chamber (airtight design) and a non-airtight compartment of scientific instruments. On the Kvant all the necessary conditions have been created for normal work by the crew: the volume of the airtight laboratory compartment is 40 cubic meters; the monitoring station for the functioning of systems and instruments, and the control organs are convenient to operate; and the life-support system creates the same conditions as in other Mir system accommodations.

The laboratory compartment with its connecting chamber is intended to house the bulk of the service and experimental gear, and part of the scientific equipment of the module, as well as active and passive docking assemblies. A horizontal configuration is used for placing the instruments and assemblies in the laboratory compartment, with a central living zone assigned, which is separated from the instrument zone by decorative interior panels. The laboratory compartment has two viewports: The first, which is 430 millimeters in diameter, is intended for placement of an optical tracker; on the second, which is 228 millimeters in diameter, is set a visual astroorientation instrument. Two more viewports, 80 millimeters in diameter, are located in the connecting chamber. They are intended for visual observation. One is oriented along the axis of the module; the other at an angle to it.

In the connecting chamber is located a lock chamber for maintaining the Glazar ultra-violet telescope (cassette loading and removal). Here the telescope control panel is

set up. In the laboratory compartment and connection chamber are five daylight lighting fixtures, which create illumination of no less than 100 lux throughout the entire module.

All panels for monitoring and controlling the work of the systems, as well as visual sensors and control organs are remoted to the crew working zone and placed in interior panels or the central control post. Within the laboratory compartment are instruments and assemblies of the following systems: on board system control; movement control; rendezvous and docking; on board measurements; maintenance of gas composition; maintenance of heat regime; docking and internal switching; testing of airtightness. In the laboratory compartment are also located the instruments of the comprehensive radio-technical system; telephone and telegraph communication system; television apparatus and separate scientific and experimental instruments and assemblies.

Without examining the operation of the above enumerated systems and equipment in detail, let us discuss in more detail only the movement control system, since its functioning is of fundamental importance for carrying out scientific research and experiments. The movement control system supports rendezvous of the module with the station, and guides the scientific apparatus to selected celestial objects and areas of the Earth's surface. The system includes sensitive elements (sensors); sensor electronics units; an on board computer system, and actuators. Gyroscopic power stabilizers installed in the module are used as actuators in the movement control system.

Why did the designers settle on this system for orientation [attitude] control and stabilization?

In order to obtain the greatest scientific return from the orbital system, it was necessary to improve substantially (by more than one order) the accuracy of the orientation of the system. In order to use the scientific apparatus effectively, it is necessary to aim the telescopes at the object being studied with an accuracy of no worse than several arc minutes. At the same time, it was necessary to increase sharply the duration of oriented flight. For virtually its entire time in orbit the Mir system has to be in oriented flight, if it is taken into account that the movement control system must also turn the system so that the solar battery panels are illuminated reliably.

All of the enumerated tests were accomplished through the use of the principles of the powered gyroscope. For comparison, let us recall the movement control system around the center of mass of the Salyut orbital station. Its actuators, which provided turns and maintained the necessary orientation, required continuous fuel expenditure. Naturally, the more precise the orientation, the greater these expenditures became. Progress freight spaceships were used to replenish fuel supplies, but even with delivery of fuel by 6-8 freight spaceships per year, Salyut could fly in an oriented position no more than 5-10 percent of its overall stay in orbit.

That is why the creators of the control system for movement around the center of mass for the Mir system took a different approach and developed a system of electromechanical actuators that use energy only from solar batteries and storage batteries. This system makes it possible to orient the Mir system and stabilize it in space without expending the fuel of the power plant. The power gyroscopes (gyrodines on magnetic suspension) used in this system as actuators are a complex electromechanical system, which includes two-stage power gyroscopes (six) with electric motors and electronic units. The rotor of a power gyroscope turns in the magnetic field of the controlling electro-magnets. To reduce friction, the rapidly turning rotor is enclosed in an airtight chamber, which joins open space.

The results of tests of the movement control complex gyrodine system, with accuracies of orientation calculated in units, open up new possibilities for space researchers.

The scientific instruments compartment is where scientific apparatus are located in the module, as well as instruments and assemblies that must be placed in the non-airtight space of the module.

The following components are included in the scientific equipment of the Kvant module.

1. The "Roentgen" international orbital observatory, created by scientists from the Soviet Union, Great Britain, the Netherlands, the FRG, and the European Space Agency. The observatory is a specialized system of devices intended for research in the field of roentgen astronomy, and for research of roentgen spectra in the 200-800 kiloelectron volt energy band. This system includes:

—the Pulsar X-1 telescope-spectrometer for hard x-ray radiation (20-800 kiloelectron volts) with a field of vision of three degrees by three degrees, developed by the Institute of Space Research, USSR Academy of Sciences, and a detector of gamma bursts of space origin with a semi-spherical field of vision;

—the "Hexe" high energy (15-200 kiloelectron volt) scintillation telescope-spectrometer, with a field of vision of 1.7 degrees by 1.7 degrees, developed by the Institute of Exoatmospheric Physics of the Max Planck Society (FRG) and Tubingen University (FRG);

—a TTM telescope with aperture (encoding) mask (2-30 kiloelectron volts), with a field of vision of seven degrees by seven degrees, developed by the Utrecht Space Research Laboratory (Netherlands) and Birmingham University (Great Britain), used for formation of images in the x-ray band of the spectrum;

—a "Siren-2" gas scintillation proportional spectrometer (2-100 kiloelectron volts), with field of vision of three degrees by three degrees, developed by the European Space Agency.

Research and experiments with the aid of the Roentgen orbital observatory are carried out in the regime of inertial orientation of the orbital complex on gyrodines, with refinement of the orientation by the crew with the aid of an astro-orientation instrument. The information is transmitted to Earth via telemetry channels.

2. The Glazar ultraviolet space telescope has been created by scientists from the Byurakan Astrophysics Observatory (USSR), with participation of specialists from Switzerland, and is intended for obtaining photographs of the sky in the 120-130 nanometers wave band. The telescope can operate manually or automatically. It is equipped with a system for automatic search, tracking and precision stabilization, which is accomplished with the aid of astral sensors and special electronics devices. Photographs obtained by the Glazar telescope are returned to Earth in Soyuz TM spacecraft.

3. The "Svetlana" automatic electrophoretic device, created by specialists from the Soviet Union for conducting biotechnological experiments to develop methods of electrophoretic purification of biologically active substances under conditions of microgravitation, and obtain experimental batches of antiviral specimens and distillates of highly-active microorganisms—products for use in the economy. The specimens are returned to Earth in Soyuz TM spacecraft.

On 9 June 1987 cosmonauts carried out the first experiments pursuant to the international program of astrophysical research with the use of the Roentgen orbital observatory. A supernova in the Great Magellanic Cloud that flared up in February 1987 was selected as the object of observation. Later, in June-September 1987, a series of observation sessions of x-ray sources was carried out in the Cygnus, Centaurus and Hercules constellations, as well as the supernova in the Great Magellanic Cloud. Measurements needed to compile x-ray maps of individual sectors of the sky were also carried out. On 13 August 1987 the instruments at the Roentgen observatory observed a powerful flareup of gamma radiation of space origin.

At the end of June research began with the aid of the Glazar ultraviolet telescope, in which Swiss specialists are taking part along with Soviet scientists. Information was obtained in the experiments about shortwave radiation of the galaxies. The objects of study were ultraviolet space sources in the constellations of Puppis, Grus, Pavo, Andromeda and Piscis Austrinus, and in the areas near the stars Alfa Pavonis and Alfa Eridani.

Research is continuing. Soviet and foreign scientists value highly the information already obtained through the use of Kvant astrophysics module apparatus.

The Cosmos-1887 Biosatellite. On 29 September 1987 the Soviet Union launched the Cosmos-1887 biosatellite.

On-board "Cosmos-1887"—the 8th[1] specialized biosatellite—which is intended to continue research on the influence of space flight factors on living organisms, scientific experimental systems with various biological objects have been set up, as well as an apparatus for radiation-physical research.

The length of the Cosmos 1887 biosatellite flight is planned for 14 days, which will make it possible to study physiological reactions of an organism, both in the initial (days 1-7) and in the transitional (days 8-14) periods of adaptation to weightlessness.

During the flight of the Cosmos-1887 biosatellite, research and experiments were carried out on monkeys and rats, concerning gravitational biology, as well as radiobiological and radiation-physical research.

The main object of research on Cosmos-1887, as on the two previous biosatellites, are two monkeys—male macaco-rhesus, four years of age and weighing approximately four kilograms each. The monkeys on the biosatellite were in special capsules.

In the experiments on the monkeys the main attention is paid to study of the vestibular apparatus, the motor system, central nervous system and biorhythms. In addition to the above enumerated experiments, before and after the flight study was also carried out of the clinical condition of the monkeys, gas and energy exchange, immunity, water and salt exchange, and the structure and biochemistry of muscles and bone tissue.

In a special unit, the design of which was similar to those used in the flights of the Cosmos-1514 and Cosmos-1667 biosatellites, there were two male rats from the Vistar line. They were provided by the Institute of Experimental Endocrinology, Slovakian Academy of Sciences, in Bratislava, CSSR. The age of the rats at the start of the flight was two months; they weighed approximately 300 grams. The experiments on the rats pursued the following objectives: study of the structural and metabolic changes arising in the organism in the transitional period of adaptation to weightlessness; evaluation of the role of various regulatory systems in the mechanisms of adaptation to weightlessness; study of the dynamics of adaptation to weightlessness of individual functional systems and the organism as a whole, based on comparison of the results obtained in this and previous flight experiments on rats.

The overall task of the experiments in gravitational biology is to seek the biological effects of weightlessness and explain the biological mechanisms of adaptation to the changed force of gravity. Primary attention is paid to

the cellular level of organization of the living object. The program includes 12 experiments with different biological objects: single celled, higher plants, insects, fish and amphibians.

Young biologists from the Central Palace of the Pioneers are carrying out two experiments on Cosmos-1887. In the first experiment, the process of regeneration of various fragments of the dissected body of a milk planarian worm is being studied. The other experiment consists of two parts. In the first part of the experiment, in a culture of Escherichia coli [intestinal bacillus] infected with a moderate bacteriophage, is studied induction of the transition, under the affect of space flight factors, of the bacteriophage from an inactive to an active state. In the second part of the experiment, in a streptococcus culture synthesis of the antibiotic nisin under conditions of weightlessness is studied.

In the field of radiobiology, research is being conducted on the Cosmos-1887 satellite on the effects of heavily contaminated particles of galactic cosmic rays on the kinetics of cellular reproduction and on the ultrastructure of cells; study of the cellular population of regenerative mechanisms in the cells of higher plants; and illumination of the capabilities of non-biological synthesis.

Along with Soviet scientists, specialists from the VNR, GDR, PNR, SRR, CSSR, U. S., France and the European Space Agency are taking part in the scientific program of the Cosmos-1887 biosatellite flight.

On 12 October 1987 the recovery vehicle of the Cosmos-1887 biosatellite landed in an unplanned area (the city of Mirnyy, Yakutsk ASSR). The monkeys Drema and Yerosha, and the other biological objects, staunchly endured the landing in the frozen Yakutsk taiga and are in good health.

New International Space Projects. Work is now being carried out on several new projects within the framework of international cooperation in space by the Soviet Union.

Preparation of the Phobos project has entered its final stage. This project envisions launching towards Mars two Soviet unmanned interplanetary stations (AMS). The expedition will have multiple purposes. Study of interplanetary outer space, the Sun, the planet Mars and Phobos, a satellite of Mars, is planned. The work is being carried out within a framework of broad international cooperation. Scientific equipment for the Phobos craft is being created by scientists and specialists from the Soviet Union, Bulgaria, Hungary, the GDR, Poland, Czechoslovakia, Austria, Finland, France, the FRG, Switzerland, Sweden, and the European Space Agency. The AMS is being launched on the Phobos project from Baykonur Cosmodrome in July 1988. The flight to Mars will last approximately 200 days.

Experiments studying the Sun and interplanetary space will be carried out on the trajectories of the flight to Mars. Study of the Sun, solar corona, and processes of solar activity have already been conducted long ago and in many countries. Important basic results have been obtained in this field. However, completed research was mainly conducted from Earth and from near-Earth orbits. In this case the research possibilities are being fundamentally expanded, since study of the Sun is anticipated at rather large angles (the angle Earth - Sun - AMS). After the launch of the AMS, as they move away from the Earth this angle will change from 0 to 40 degrees (upon reaching Mars), and by the end of the expedition even up to 180 degrees. Observations of the Sun simultaneously from on board the AMS, from Earth and from near-Earth satellites will present a unique opportunity to clarify the spatial structure of the chromosphere and corona, as well as to observe processes not visible at this time from Earth.

A so-called solar complex of scientific equipment is being placed on board the AMS for the solar research. It is intended for analysis of optical, ultraviolet, x-ray and gamma radiation. It is anticipated that x-ray pictures of the Sun and its corona will be obtained; the intensity of ultraviolet radiation of the Sun will be regularly registered; and gamma flareups of solar and cosmic origin will be studied. An experiment to study solar oscillations is of great interest. They are associated with explaining the internal structure of the Sun and the processes taking place in its interior. As is known, solar pulsations were discovered by scientists at the Crimean Astrophysics Observatory, USSR Academy of Sciences. Research in this direction promises interesting results related to the structure and dynamics of the Sun, and the conditions under which the Phobos expedition is being carried out are very suitable for such measurements.

Research with the aid of plasma complex instruments will also be carried out in the trajectories of the flight to Mars.

Upon reaching Mars, the AMS first will enter elliptical orbits around the planet, which then will be changed to circular. From circular equatorial "observation orbits" autonomous navigation measurements of the movement parameters of the AMS relative to Phobos are conducted. Simultaneously, television pictures of Phobos are transmitted to Earth to define its form and details of relief more accurately. About a month is allotted to this stage of the expedition. After the information is processed by computers on the ground, a maneuver by commands from Earth is planned to switch the AMS to a circular areocentric orbit synchronous with Phobos. The next two months are allotted to obtaining and processing information making it possible to "let down" the AMS to a distance of 35 km from the object being studied, Phobos. Beginning from this distance, further approach of the AMS to Phobos is accomplished by commands from on board instruments.

At "hovering" altitude (approximately 50 meters), comprehensive investigation of Phobos is planned for 15 minutes: television photography; radioscopy of the internal structure of Mars' satellite; laser and ion-beam irradiation of its surface with evaporation of a sample substance and subsequent study of the chemical and physical properties of the "evaporated" substance by instruments located on board the AMS. At the end of the "hovering" period, landing probes of two types are detached from the AMS, which carry out research right on the surface of Phobos. After this the AMS will shift to their assigned areocentric orbits to continue the scientific program of the expedition: remote research of Mars and its atmosphere; study of near-Mars space; and further study of the Sun.

The overall length of the expedition is almost one and a half years (460 days).

The central part of the scientific program of the expedition is the study of Phobos. The nature and origin of the Martian moons is still largely enigmatic. Phobos is potato-shaped, with dimensions of approximately 30 x 20 km. Numerous hypotheses exist that try to explain how the satellites of Mars ended up on areocentric orbits. According to one of them, Phobos and Deimos can be associated with class C asteroids captured by Mars.

Phobos has a very dark (albedo approximately five percent), rough surface, pitted by numerous craters caused by objects striking the satellite. Entirely unexpected formations were discovered on Phobos—numerous nearly straight and approximately parallel ridges, 200-300 meters wide and 20-30 meters deep. Almost all of them are located in the largest crater, Stickney, which has a 10 km cross section; i.e., more than a third of the cross section of Phobos itself. The mass of Phobos is approximately 1.5 x 10 -8 power that of Mars; its average density is approximately two grams per cubic centimeter. Thus, Phobos cannot consist of dense soils, remelted by volcanic processes, from which the crust and mantle of planets of the Earth group are composed. Spectral observations of changes in the reflective ability of Phobos have shown that these changes are of the same nature as those of carbonaceous chondrites, a well known type of meteorite.

The comprehensive program for the study of Phobos anticipates research of the surface of this satellite of Mars (chemical and mineral composition, high-resolution cartography, physical attributes and radiophysical characteristics); its inner structure (seismology, large structures), and parameters of orbital movement (free and forced librations, secular deceleration). Study of Phobos will be carried out while the AMS approaches to within several tens of meters of its surface, and during low-speed flight over Phobos.

The active remote sensing of its surface will become one of the main elements of the study of the Martian satellite. In the Lima experiment, a laser beam with an energy of approximately 0.5 joules, focused on the surface of Phobos to a diameter of 1-2 millimeters, for a very short period of time (10 nanoseconds) will cause explosion-like evaporation and ionization of the substance. The ions that are formed fly apart, and some of them strike a special instrument, a reflectron, installed on the AMS. Here the mass of the particles will be analyzed according to the time of their flight from the surface of Phobos to the instrument "trap."

In the Dion experiment an ion gun will emit ions of krypton, accelerated to an energy of 2-3 electron volts. These ions will begin to dislodge secondary ions from the surface layer of Phobos, which are then registered on board the AMS by a mass spectrometer. The experiment will make it possible to study the composition of the surface layer of the Martian satellite, and determine in it elements implanted by solar wind. As the AMS passes over Phobos, the soil will be studied at approximately 100 points by the methods used in the Lima and Dion experiments.

The surface relief, subsurface structure and electrophysical characteristics of the soil on Phobos will begin to be studied in the Grunt experiment by the radiosonde observation method.

The television system will photograph in three spectral bands, and scientists hope to obtain synthesized (color) pictures, in which details of the surface a little larger than six centimeters in size will be distinguishable. Simultaneously, it is planned that spectrometry of the photographed sectors will be accomplished in 14 zones, with a resolution of 50 nanometers. With the aid of a revolving mirror, the lens of the television system can be directed not only on Phobos, but also on Mars, and on the brightest stars, which is important for solving navigation tasks.

Finally, gamma and infrared spectroscopy will be used to study Phobos. This will make it possible to judge the thermal and reflective properties of the surface of the Martian satellite, and its mineral composition. Information will also be obtained about the main rock-forming elements (iron, silicon, aluminum, calcium, magnesium, and others), as well as natural radioactive elements (uranium, thorium and potassium).

An important role in the study of Phobos is allotted to the landing probes. One of the landing probes is designated the long-term autonomous station (DAS). The DAS is released from the AMS when the latter is a distance of several tens of meters from the surface of Phobos. After its release the DAS begins slowly to "fall" to the surface of the Martian satellite; the relative speed of convergence of the DAS and Phobos will be several meters per second. Oriented contact with the surface is anticipated, for which the DAS after release is made to revolve round its longitudinal axis. After contact, the DAS is anchored to the surface.

The task of the DAS is to conduct scientific experiments on Phobos that require lengthy measurements. These include studies of celestial mechanics, which are accomplished with the DAS radio system and ground receiving and transmitting antennas (the main information sought consists of range measurements, with an expected accuracy to five meters); study of the librations of Phobos, carried out through autonomous measurements of the angular position of the Sun by an optical sensor and through radio interference measurements according to signals from two transmitters carried on the surface of two DAS; registration by a seismometer of seismic noises, caused by the gravitational field of Mars, falling meteorites, and thermal expansion during the transition from night to day.

Another group of experiments on the DAS [long-term autonomous station] is to study th composition of elements of the surface layer, their structure and physical and mechanical properties. The bulk of the information about the composition of elements will be obtained from on board the AMS by remote methods. Direct measurements with the use of the DAS are necessary for calibration and to facilitate interpretation of the data from remote measurement. The DAS will operate on the surface of Phobos for about a year.

One more variant of a landing probe is being examined; one that moves (more accurately, jumps) across the surface of Phobos. After the landing and settling of the apparatus on the surface, the probe is switched to an operating position with the aid of "feelers" on the orienting device. Then scientific measurements are carried out and information is transmitted by radio to Earth. The next cycle of measurements is carried out after the probe jumps a distance of up to 20 meters with aid of a repelling device. Again, after quieting, the probe is ready for a repeated operating cycle. The number of cycles is up to 10. The scientific apparatus of the probe includes a device for measuring accelerations upon collision with the surface; an x-ray-fluorescence spectrometer to study the chemical composition of the surface layer of the soil; a penetrometer to study the physical and mechanical characteristics of the soil; and a magnetometer to measure magnetic fields.

Thus, with the aid of landing probes, for the first time in the history of space research, it is planned that by direct measurements, structural data and the chemical and mineral composition of the surface of Phobos will be obtained.

Let us say a few words about the study of Mars and its environs by instruments included in the planetary complex of scientific apparatus. During the orbital flight of the AMS around Mars, it is anticipated that its surface will be surveyed by remote sensing methods in the visible, infrared and gamma bands of the spectrum. There are plans to obtain a temperature map of the surface of Mars; study the daily and seasonal dynamics of its temperature regime; measure the thermal inertia of the Martian soil; and, seek sectors of emission of endogenous heat and areas of permafrost. Data will be obtained about the mineral composition of the surface of Mars. Using gamma spectroscopy, plans are to determine the content of the primary rock-forming elements (oxygen, magnesium, aluminum, silicon, calcium and iron) and natural radioactive elements (uranium, thorium and potassium). These data will make it possible to judge the nature of the soils, their chemical composition, and the degree of differentiation of soils in the process of their formation.

A series of experiments to study the atmosphere and ionosphere of Mars is also anticipated.

Thus, in July 1988 two AMS [automatic interplanetary stations] will be launched toward Mars, each of which will be equipped with more than 30 scientific instruments. With their aid, plans are to conduct an extensive program of unique comprehensive investigations of several objects in the Solar System. The results of this research will advance our understanding of one of the basic problems of natural science—the problem of the origin of the Solar System, the planets and their satellites.

Geophysicists in the socialist countries expect much from the Aktivnyy and Apeks projects.

The main scientific task of the Aktivnyy project is comprehensive research on the processes of the spreading of very low frequency electromagnetic waves in the ionosphere and magnetosphere of the Earth. Features of this project are the use of an autonomous subsatellite with a correcting propulsion system; a far-flung registering network of Earth measuring points; original registering equipment on the main space apparatus, with a 20 meter long antenna deployed in space and a complex analyzing system; etc. Plans are to launch the Aktivnyy project satellite in 1988.

The main scientific goals of the Apeks project (active plasma experiments) are initiating and modeling of geophysical phenomena in near-Earth plasma, by injection of charged particle beams into the plasma and study of the basic processes in the plasma, under conditions inaccessible in laboratory research. As in the preceding project, the main satellite in the Apeks project will carry an autonomous maneuvering subsatellite. Launch of the main satellite of the Apeks project is planned for 1989.

Scientists and specialists from practically all countries participating in the Intercosmos Program are working on the Aktivnyy and Apeks projects.

The Interbol project is also causing great interest. The objective of the project (its implementation is planned to begin in 1990) is to continue on a qualitatively new level study of solar-earth relationships, in particular the mechanisms by which the energy of the solar wind is transported to the magnetosphere of the Earth. Due to the use

of a single system of four spacecraft (two Progress- type satellites and two small autonomous subsatellites released from them), measurements will make it possible to study the interrelationship of phenomena in key areas of the magnetosphere. Scientists and specialists from the USSR, NRB, VNR, GDR, Republic of Cuba, PNR, SRR, CSSR, France, Sweden and the European Space Agency are taking part in the preparation of experiments and creation of scientific apparatus for the Interbol project.

A basic feature of the Aktivnyy, Apeks and Interbol projects that should be emphasized is that these projects have major scientific objectives, and at the same time their results will be of great practical value.

FOOTNOTE

1. Since 1973, seven specialized biosatellites have been launched in the Soviet Union: Cosmos-605 (1973); Cosmos-690 (1974); Cosmos-782 (1975); Cosmos-936 (1977); Cosmos-1129 (1979); Cosmos-1514 (1983) and Cosmos-1667 (1985). Beginning with Cosmos-782 research has been conducted within a framework of international cooperation.

State Commission Chairman Kerimov Recalls First Manned Spaceflight

18660180a Baku BAKINSKIY RABOCHIY in Russian 12 Apr 88 p 3

[Article by K. Isaakov, Flight Control Center, "Breakthrough into the Unknown; Today is Cosmonautics Day"; first six paragraphs are source introduction]

[Text] **At the request of the BAKINSKIY RABOCHIY, the chairman of the State Commission for Soyuz Spaceships, Lieutenant General K.A. Kerimov, shares his recollections about the first spaceflight and Yuriy Gagarin.**

On the eve of the holiday, activity at the Flight Control Center seemed routine. Yes, space travel has become so firmly fixed nowadays in our consciousness as something of an everyday occurrence that it is already being perceived as routine earnest work.

But let us recall the beginning of the 1960s. Each new breakthrough to the stars was a holiday for us then. And that first, very first, Gagarin's... This was a victory for the human spirit and for human thought.

At that time, we did not know the people and the long years, which were involved in the preparation of this victory at the cost of the greatest effort of will and intellect. And, naturally, we had no idea that among them was our fellow countryman, Kerim Aliyevich Kerimov.

A student and companion-in-arms of Sergey Pavlovich Korolev, the space designer at the beginning of the 1950s, he was appointed as an administrator right off of several state commissions associated with the investigation of the universe. But, for many years, this was unknown to us...

Only in August of last year did our newspaper present to its readers the chairman of the State Commission for Soyuz Spacecraft, recipient of the Lenin Prize, twice recipient of the USSR State Prize, bearer of the Order of Lenin, of two Order of Labor Red Banner, and of the Red Star Order, Lieutenant General K. Kerimov. Today, at our request, he shares his recollections about the first launching of a person to the stars and about the feat of the first space explorer, Yuriy Gagarin.

Yes, it is possible to say, from a detached point of view, that even now flights into space are not perceived as romantically as a quarter of a century ago. But, each time I greet our boys who have returned to the earth from a space watch, I recall Gagarin's return and his flight. And the feelings, you know, are such, well...

I think that it is not just a matter of the specifics of our work—the connection with the boundless, the unknown will hardly become a matter that is finally routine. And hardly so in the personalities of such people as Sergey Pavlovich Korolev and Yuriy Alekseyevich Gagarin. They, in a surprising manner, set the tone of our attitude towards everything associated with space. And I am still glad that I was able to work together with them.

At that time, during the period of preparation and launching of the first Vostok ship, I headed up the administration which handled the monitoring of the planning and manufacturing of space rockets and craft for flight in the automatic operation version. And along comes Sergey Pavlovich with a proposal about establishing a special space complex for manned flight.

In the first approximation, this seemed almost fantastic. But Korolev substantiated everything. He turned to the government. They approved the idea and a corresponding decision was made. Our administration was entrusted with the supervision and acceptance of these rockets and ships.

For the developers, as well as for us, the customers, the task of establishing such a complex with the goal of man travelling to the stars and into space with, naturally, an unconditional guarantee of a return to the earth was, of course, unusually complicated and something new. But, although we viewed it generally as a surprise, for Korolev this was the realization of a long-held dream.

He, as they say, fell on this work greedily and pounced on it with all the mighty strength, passion and persistence he possessed. Everything else was shoved aside.

The matter, by the way, for all of us was still also a political one. We understood quite well that the USA, having lost first place to us in the launching of the first satellite, would be striving to take revenge iin the matter of manned flight.

Our administration, staffed by young specialists, had specific experience in the development and testing of rockets and automatic spacecraft, of course. But the presence of a man in the spacecraft dictated additional, hitherto unknown requirements.

The Vostok ship, which was to carry the first earthling into space, was developed taking these special requirements into account. As far as the rocket was concerned, it already existed—in the version used previously for launching automatic craft. There was no time to think about developing another.

So it was decided: they would take as the starting point the rocket that placed our first satellite into orbit in 1957 and rework it, adding a third stage to the two already existing stages. In addition, they tightened up the method for manufacturing the rocket as a whole and its individual components. Also introduced was an additional check with the notation "for manned flight."

It did not go easy for us, the customers and examiners, and especially for the manufacturing plant's specialists. Indeed, in essence, it was necessary, on the basis of the existing rocket, to develop a completely new and trouble-free one (later, by analogy with the ship, it was also called Vostok).

In the process of carrying out this task, S.P. Korolev did not lose sight of one single detail. He personally checked everything. After all, this was his most precious little child! Disagreements which arose in the course of events between the acceptance personnel, the manufacturers and the planners were settled only with his participation. Therefore, taking into consideration the requirement for a high degree of reliability for both the rocket and the ship, questions of this nature, as a rule, were decided in favor of the acceptors. Sergey Pavlovich managed to get everything done. And so, while still at the plants, on the stands and in the laboratories, the last components of the rocket and the ship were being worked on, Korolev had already staffed in Moscow the working group of the State Commission for a visit to the cosmodrome.

At that time, it was decided that about 30-40 days would be spent on flight tests in order to check everything on the spot, down to the last little screw. And, therefore, at the beginning of March, we all flew to the cosmodrome. We set about preparing the rocket and the ship. Several days behind us, the group of future cosmonauts also showed up at Baykonur.

Who would fly first was still not clear at that time. Later, each of the names of those who made up that group would become known to the entire world. But, for the time being, to us they were simply young pilots who had undergone the most earnest preparation and training and who were exceptionally healthy. Supervising the work with the flight candidates, General N.P. Kamanin proposed two possibles as the first cosmonaut—Yuriy Gagarin and German Titov. The nominees were scrutinized very carefully. As a result, the selection fell on Gagarin—he was also confirmed by the State Commission. And Titov was named the back-up man.

I remember clearly that morning of 12 April 1961—at Baykonur, it was a particularly fine spring morning.

Usually on the day of a launching, the complex's pre-flight preparation takes 4-5 hours. Yet then, everything was for the first time.

The most crucial moment had arrived. Right here, at the launch site, a meeting of our State Commission took place. The decision was made—the rocket was to be fueled.

We no longer sat around in the room. State Commission Chairman Konstantin Nikolayevich Rudnev, Sergey Pavlovich Korolev and I went outside. We were walking around the launchpad, waiting for the bus with the cosmonauts to arrive.

We were nervous. The tension—it can not be described in words. For some reason, we were quiet. Now and then, Sergey Pavlovich interrupted the silence and asked whether or not the testers had forgotten to check and evaluate one or another detail which ensure the complex's reliability. He understood, however, that they had not forgotten, but he asked all the same: the responsibility cannot be compared with anything else. Well, it is just like before a long trip when you check: did I forget my ticket, papers, toothbrush. Although, that is hardly a good comparison...

From time to time, clear commands were heard over the loud speaker: the rocket and ship are ready for flight. The time remaining until the launching was announced.

Finally, the bus. Here were Yuriy Gagarin and German Titov, accompanied by the doctors.

Gagarin got off the bus and headed towards us. And there was such a feeling of affection towards this fellow, such a feeling of concern for him! Right then, he was next to us, but, in just a few moments he would be somewhere far away, in the black cosmic abyss. Sergey Pavlovich and Konstantin Nikolayevich hugged and kissed Yura (at that time, the ban against touching a cosmonaut before a flight did not yet exist).

We all headed together towards the elevator. Gagarin, accompanied by the chief designer, got into the elevator, which then ascended. Then he went out onto the ramp and waved goodbye to us. And—he disappeared behind the ship's hatch.

From this moment on, communication with Yuriy Alekseyevich would be accomplished through the radio and the on-board television system. Communicating with him was his back-up—German Stepanovich Titov.

After the historical "We're off!" the rocket swiftly disappeared from the range of visibility, while its powerful engines thundered. "Well, that is that," it simply occurred to us then.

We looked at Korolev. What was this man feeling? Suddenly, his face broke out in a smile of immeasurable, always carefully concealed weariness.

"To the command post," he said briefly. And off we went. From the command post, communication was maintained with the Vostok.

The 90 minutes lasted a terribly long time. There was only one thought: "If only everything is alright"

The nervous tension began to decrease little by little after the ship's braking engine began working. Then the report came: the parachute had deployed, everything was all right.

But only when the news came that Gagarin had landed safely in the specified region, not far from Kuybyshev, did everyone breathe easily.

At Sergey Pavlovich's command, the State Commission's main group boarded a previously prepared airplane. And off they went to there, to Kuybyshev—the sooner to see Yuriy Alekseyevich and to embrace the earth's first space hero!

Since that time, we have met a lot of starmen. And we hugged them, too, and congratulated them.

And every time I see the figure heading to meet me of a man who has just been involved in the secrets of the universe, it seems to me that there is something Gagarin-like in his manner.

Notes Of Former State Commission Chairman Lt Gen G. A. Tyulin

18660181a Moscow KRASNAYA ZVEZDA in Russian 2, 3, 5 Apr 88

[Article by retired Lieutenant General Georgiy Aleksandrovich Tyulin, former chairman of the State Commission for Manned Ships, professor, doctor of technical sciences, recipient of the Lenin Prize, Hero of Socialist Labor: "Task for the Future; Notes of the State Commission Chairman"; first paragraph is source introduction]

[2 Apr 88, p 4]

[Text] **Today we begin publishing notes of recollections, behind which are the strenuous labor and heroic spirit of the space days. Their author is retired Lieutenant General G. A. Tyulin, recipient of the Lenin Prize and Hero of Socialist Labor. Georgiy Aleksandrovich, a professor and a doctor of technical sciences, was, at one time, chairman of the state commission which was in charge of the launches of manned and unmanned spacecraft.**

The First State Commission

The year 1962 was drawing to a close. Yuriy Gagarin, German Titov, Andriyan Nikolayev and Pavel Popovich had already been in space orbits, parallel operations were going on with unmanned craft, the first paths to the remote planets were being blazed, the Cosmos satellites were being launched, and new 'aunch vehicles were being tested...

I remember the nighttime phone call from Korolev: "Did I wake you?" "No, I hadn't gone to bed yet." "All the same, forgive me for such a late intrusion." "I forgive you. What's happening with you?" "Not with me, rather with you. It is you they intend to appoint as chairman of our commission." "Me?" I said in surprise. "You," resounded the reply in the receiver. "Get ready to do battle with me." He began to laugh. "Okay, go to sleep. Good night."

I heard the sound of the dial tone before I had time to answer. And, really, what could I say to him? The conversation was conjectural, although hints had been heard previously on occasion...

The State Commission for Manned Ships was headed at that time first by Konstantin Nikolayevich Rudnev (he launched Gagarin) and then by Leonid Vasilyevich Smirnov. I already knew both of them from my ouw previous work. Rudnev frequently visited our SRI [Scientific Research Institute] and was keenly interested in the course of matters. Unpretentious in his manner and attentive to people, he listened with enviable patience to the opinions of opponents without putting them into a rigid provisional framework. In a difficult moment, and such did occur, more than once, he managed to relieve the tension with a joke and he was witty, but short-spoken. He conducted himself calmly and with restraint in "critical" situations and did not "chew out" anybody who made mistakes.

L. V. Smirnov, an engineer to the core, extremely particular and meticulous during the analysis of complicated technical questions, categorically rejected half answers and half measures and valued highly regularity in work and demanded that creative use be made of each and every minute. Each and every one! He invariably addressed subordinates using the polite form of "you" and conducted himself tactfully and in a natural manner.

With all their distinctiveness, both chairmen were similar in their management style, which was expressed in their exactingness and attention to people, and each had accumulated considerable work experience in industry during the years of the Great Patriotic War and, of

course, a profound understanding of all the complexity and responsibility of what the numerous collectives—scientific, design, production—were doing for the country's spaceflight program.

I will not venture to say that contact with them was simple and smooth. Cosmonautics had taken only its first steps and, therefore, there arose quite a few problems and the most complex questions and all this required rapid and exceptionally clear-cut decisions. But these steps, I reiterate, were firm and certain.

Now, after so many years, it should be acknowledged that the state commission is a highly complex organism. The circle of its responsibilities is diverse and extensive. The main thing, if this is separated from all the rest The words "tests" and "complexes" are not conditional concepts, but rather, specific concepts. After all the plant and bench tests, the "object" (this is what we called it) is checked out under actual space conditions. And not only the craft or the launch vehicle themselves, but also all the ground-based and space-based systems in the complex.

The State Commissions examine and approve the flight programs presented by the technical management group, the design bureaus, the Academy of Sciences, the Cosmonaut Training Center, and the cosmodrome for spaceships, orbital stations, unmanned craft and interplanetary automatic stations, as well as the programs for scientific and applied research; they analyze the results of the launch vehicles' pre-launch preparation and the readiness of all the ground services: the communications and tracking systems, the command and measurements complex and the Flight Control Center... The State Commission makes the decision to allow all these "links" to join in the conducting of the flight tests and also approves the crews: the main and the back-up.

Over the various years, the make-up of the state commissions has changed. And this is natural. The programs themselves changed and became more complicated and a greater number of organizations participated in them. The technical management group was headed by S. P. Korolev and the scientific by M.V. Keldysh. In the first few years, all the aviation support was handled by Marshall of Aviation S.I. Rudenko and the cosmonauts' training by General N.P. Kamanin. Included in the make-up of the technical management group were the chief designers (members of the "Chief Designers Council")—V.P. Glushko, N.A. Pilyugin, M.S. Ryazanskiy, V.I. Kuznetsov and V.P. Barmin, as well as chief designers A.M. Isayev, S.A. Kosberg, S.M. Alekseyev, G.I. Severin, A.F. Bogomolov, and Korolev's deputies—B.Ye. Chertok and L.A. Voskresenskiy...

The members of the state commission included representatives of the ministries and departments participating in the development and manufacturing of the individual systems of the spaceships, launch vehicles and ground and launch equipment, representatives of the cosmodrome, as well as our well-known scientists—academicians A.Yu. Ishlinskiy, V.A. Ambartsumyan and others.

Each of the persons named by me possessed knowledge and experience, thoroughly knew their own field, was an innovator in the most direct sense of this word and was responsible for the progress of the work and the completion of the entire program. Heading up such a commission is an honor, but not a simple job.

Onward, To Mars!

At the end of 1962, I was appointed to head up the State Commission for the launching of one of the first interplanetary laboratories—Mars-1. We were facing the investigation of the area of space along the flight path, the checking of the quality and stability of radio communication over interplanetary distances, the photographing of Mars and the transmission of the obtained photos and scientific information back to earth.

On 12 February 1961, the year of Gagarin's launch, the Venera-1 set out on its journey. It passed Venus at a distance of around 100,000 km and went into orbit as a satellite of the Sun.

The Mars-1 station (just like the first Venus station) was made by the design bureau headed up by S.P. Korolev and selected for launching it was the four-stage Molniya-style rocket, which was developed based on the famous "semerka" (R-7). Sergey Pavlovich Korolev was not feeling well at that time and the technical management group at the cosmodrome was run by B.Ye. Chertok.

They planned a complicated matter. They recalled F.A. Tsander's visionary call "Onward, to Mars!," and worked with great enthusiasm, but the preparations proceeded slowly and there was a fair amount of criticism, primarily about the radio equipment. The radio operators at the cosmodrome met a large number of times. Each of the developers' "firms" defended their own interests and advanced their own demands, at times to the detriment of the "particular and general conflicts" be eliminated?

Time sped by. The planets' age-old race does not permit the shifting of the calculated time frames and the considering of what has been planned in terms of days and hours that are convenient for a state commission. Nature allotted for the launching only strictly specified dates and a time of day with a tolerance measurable in seconds.

In order to preclude possible disruptions, the State Commission made a decision to invite to its meeting Minister V.D. Kalmykov. Valeriy Dmitriyevich headed the State Commission for Radio Electronics. I knew him as a person of superior erudition and a very experienced

examiner, capable of looking into a complicated technical problem with surprising rapidness. The reasoning was: he is a minister, he is a doctor of technical sciences and, as they say, he holds all the cards in his hands.

Kalmykov flew to Baykonur the following day. He headed straight from the airport to the production and engineering complex not far from the launch site. By evening, the commission received an exhaustive report on the systems and understood that the launch time frames would be maintained and highly accurately.

On 1 November, 1962, the weather was no cause for joy. It was pouring. The rocket could barely be seen. A solid wall of water and a dense fog covered the launch building and the servicing girders. A bright flash pierced this gray shroud and disappeared very quickly in the low cloud cover. "Onward, to Mars!" someone said, repeating Tsander's words. Upon hearing them, I thought: "At least, there are no such incessant rains there..."

After the first few communications sessions, the State Commission flew to Moscow. No sense in sitting there at Baykonur for half a year. Distressing news awaited us in the capital: according to the telemetry data, it turned out that the pressure in the Mars-1 craft's attitude control system was dropping sharply. The report received from space was a death sentence for our Mars craft.

"The first pancake is always lumpy," we reassured ourselves, understanding full well that such a "pancake" was very expensive. Yet, all the same, the craft's reserve capabilities turned out to be enormous. Up until 21 March 1963 (more than 140 days), 61 radio sessions had been conducted with the station and more than 3,000 commands had been transmitted to the craft.

New work was awaiting me, a new state commission. How will things shape up there? How will the program go? I frequently returned to these thoughts after that nighttime call from Korolev.

The Vostok Program

The basic tone for all the work at Baykonur was set by the technical management group. More accurately—by S.P. Korolev. He reported to the State Commission about the progress of all the preparatory work, first in the MIK Building (assembly and testing building) and later on the launch pad. The methods for all the cycles and the corresponding documentation of the main OKB [Special Design Bureau] and the other design organizations had been approved for four Vostok launches in all and, naturally, they were refined and reworked with each successive operation.

Along with the regular teams which performed operations in the MIK Building and at the launch site (including the bunker and the measuring services), also participating in the work was a large number of the developers' representatives: testers, senior designers and technicians... They functioned in a supervisory capacity and, at times, served as back-ups for the main operators.

It happened that one or another chief designer wanted to conduct additional measurements or checks and would call the people he needed to Baykonur. The commission alertly, to say the least, kept tabs on any kind of "additions" to the "regular list." And even Korolev himself got annoyed whenever his eyes came upon any "extra people."

I remember how, one time, he watched for a long time from the sideline the work of the testers. Particularly, one of them, who fussed more than all the others and gave questionable pieces of advice, which caused confusion and nervousness. Korolev beckoned the senior engineer over.

"Who is that?" he said, indicating with his eyes the person he did not like.

I immediately got the feeling that a storm was brewing and that he had been storing up this dissatisfaction within himself for far too long.

"Our comrade" was the answer given to him.

"What is 'our' supposed to mean?" Korolev flared up. "Could there really be others here? From what organization, what is he responsible for? What task is he performing? Specifically. Now, at this minute."

"Excuse me, Sergey Pavlovich, but everything is going according to schedule," said the senior engineer by way of justification.

"Trains go according to a schedule," snapped Korolev. "Not one extra person, not one extra motion, not one extra detail—this is our rule, which is supposed to be observed."

Now, of course, order is order and I do not want to make excuses for the violators. But, indeed, we had only just begun and it was difficult to determine whether this person was extra or not. He might not be necessary today. But, tomorrow...

Special situations arose when it was necessary to eliminate a discovered malfunction or failure in the operation of some system or unit. It also happened that the discovered defect suddenly disappeared. As if it had never been. But, in fact, it had been! And we knew about it! And we were alarmed!

A "self-eliminating" defect was considered to be the most dangerous type of defect. It has disappeared now, but what if it appears again, when there is no possibility of eliminating it, when an irreversible process has begun? Something like that is fraught with the possibility of

ruining the entire program. The efforts and resources expended on the development and construction of the unique equipment, as we say, will go down the drain. This is intolerable.

A "self-eliminating" defect absolutely had to be tracked down and explained. In all its details. And then—eliminated. And repeated checks had to be made...

This is why the specialists from the undesirable "additions" appeared. But, I reiterate, the State Commission did not approve of such a practice.

The regular list for each launch (for each "operation," as it was then customarily called) was confirmed by the State Commission. This included, first and foremost, the MIK's team and that of the launch site—that is what the groups of permanent specialists were called. But it also included the visitors—they were called "expeditions." The list of all the specialists sent to the cosmodrome turned out to be very lengthy, despite all the cut-backs on our part. And, of course, for each one, a work place had to be determined (more accurately—"carved out"), not to mention the arrangements that had to be made for housing, food, transportation, etc.

At that time, the construction of the cosmodrome was still continuing and the management team had to solve the most complicated problems.

Yes, that is the way all these things were...

[3 Apr 88, p 4]

The Launch Is Postponed

[Text] May and June in 1963 turned out to be hot. Summer comes swiftly to Baykonur. It begins to bake already at the end of April and, subsequently, the thermometer column just creeps higher. With every passing day, it was getting hotter and hotter and only with the onset of darkness did a slight coolness arrive.

The Vostok-5 and -6 were being prepared for launching. The State Commission arrived at the cosmodrome early and listened to the reports of the technical management team, the individual chief designers of the on-board systems, the launch site operators and the representatives of the search-and-rescue service... Two days prior to the planned launch, they confirmed the ships' commanders and their back-ups. For the Vostok-5, it was Valeriy Bykovskiy and Boris Volynov and, for the Vostok-6, it was Valentina Tereshkova, Irina Solovyeva and Valentina Ponomareva.

On 12 June, at the appointed time, Bykovskiy took his place in the ship. The pre-launch checks and the preparation of the booster were begun. The launch command was reporting on the progress of the work and the completion of operations when the "Solar Service's" message arrived concerning the recording of the heavenly body's increased activity. "What does this mean?" I asked. "We recommend postponing the launch for a day," was the response. There were consultations and meetings (I think that, at that time, the commission members were not very well acquainted with the details of this solar phenomenon) and they decided to hold off on the launch.

The command was given: "Stand down, bring the cosmonaut back down to the ground, everyone is to act according to this alternate procedure." They helped Valeriy Bykovskiy climb out of the ship and escorted him to the elevator. The compartment slowly crept downwards...

On 13 June, the story with the solar activity was repeated and Bykovskiy again made the trip from the assembly and testing building, where they dress the cosmonaut in the pressure suit, to the ship and back.

More days went by. It is possible to imagine the state of mind of a person who has been removed from a rocket twice. The same thing happened later, although the reasons were different. Today, a crew is mentally prepared for the fact that a launch might be postponed for several hours or put off till another day. Today, we have many years of experience behind us, which has made it possible to "accumulate," "survive" and "have a keen feeling for" the most diverse situations. Back then, though...

On 14 June they were able to "deal with" the solar activity. Bykovskiy took his place in the ship for the third time, but the "bad luck" did not stop here.

After the rocket had been fueled, a "bug" was discovered: during the final check-out operations, a comment was made about the operation of one of the most important systems of the guidance equipment—the hydraulic instruments unit. The "iron-clad rule" went into effect: diagnose the problem, correct it and preclude the possibility of a recurrence.

The State Commission held an urgent meeting. They listened to the reports of the technical supervisor and the system's chief designer and made the decision: remove the equipment unit, replace it and conduct, first, autonomous systems tests and, then, general tests as well, of the entire rocket.

It would seem that what had to be done was simple, logical and completely clear. But, indeed, all this required time, not minutes, but hours. There were not that many of them allotted to us for the pre-launch preparations. We could launch the rocket at any time. The complication lay in the fact that the flight program had been scheduled according to days, hours and orbital

revolutions and the landing region had been specified. It had been intended that the cosmonauts land during daylight hours. At that time, we had still not conducted such operations at night.

The nervous tension increased, although everyone was trying to conceal his own feelings and not shown his own agitation to the others. One of the high-ranking supervisors present at the launch addressed me.

"Georgiy Aleksandrovich," he began with the all the tact he possessed, "would it not be better to postpone the launch for another day."

I understood his concern, but it was not possible to disregard the cosmonaut's state of mind as well. Would a person be able to maintain his fitness for work in space, which for all of us was still enigmatic to a great degree, after such "ups and downs"? The situation was complicated not just by the fact that, in such instances, the chairman is supposed to take the responsibility himself. And it was not this, I must admit, that disturbed me. Military personnel understand full well the concept of "subordination"... But it was no accident that the commission has the status of a State Commission.

After repeatedly weighing all the "pros" and "cons" and consulting with S.P. Korolev and M.V. Keldysh, I made the decision: continue the work and do not postpone the launch. This was the judgment I reported at the regular meeting of the State Commission. They supported me.

I can recall now all the tension of those June days and again I go back to Valeriy Bykovskiy and I can not render him enough due for his self-control, his restraint and his calmness. It seemed as if he were not even particularly interested in the reasons for the delay, his reports sounded clear and the telemetry data confirmed that the cosmonaut was feeling fine.

A lot of the credit for this belonged to Yuriy Gagarin. He was in contact with the "Yastreb" ["Hawk" - callsign], joking and fooling around, relaying music and attributing the launch delay to various trifles.

At 1500 hours Moscow time, the Vostok-5 began its trip into orbit.

Fly, Chayka! [Sea Gull]

On 16 June we sent into space the first woman cosmonaut, Valentina Tereshkova. This time everything went strictly according to schedule. The rocket departed the launch site without any delays.

"Fly, Chayka!" we admonished Valentina Vladimirovna upon departure.

"Certain unexpected things occurred much later, during the landing. In the Vostok ships, the cosmonauts ejected from the ship and descended by parachute. Valentina Vladimirovna, in violation of instructions, looked up to the side of the parachute canopy, where the upper line of the pressure suit's helmet was and... This is when this most unexpected thing happened. A "piece of iron" smacked her on the nose and, two days after this, the cosmonaut had to powder it a bit more than usual.

The fate of V. Bykovskiy's back-up man—Boris Volynov—is well known: he was launched in the Soyuz-5, together with Evgeniy Khrunov and Aleksey Yeliseyev. He returned to the ground alone, after his comrades had transferred to the Soyuz-4, which was piloted by Vladimir Shatalov. And this landing turned out to be a not very soft one. I recall the nighttime meeting with him at Baykonur. He was bearing up splendidly. In July and August of 1976, he spent 49 days on board the Salyut-5, together with Vitaliy Zholobov.

Things turned out to be more complicated for Tereshkova's back-ups. They spent a long time preparing for their own launches, completed the Zhukovskiy Academy and received "Pilot-Engineer-Cosmonaut" diplomas, but, after S.P. Korolev's death, the plans for the space flights changed and only after 19 years did a woman cosmonaut again appear on board a spaceship: she was Svetlana Savitskaya. Irina Solovyeva and Valentina Ponomareva continue to work in engineering positions...

One Evening And Morning In January

The memory often returns to the past. I had ties with Sergey Pavlovich Korolev from the many years of work in the space industry and on the State Commission. This was preceded by long years of friendship, beginning with the victorious year of 1945. In all probability, I could write a book about the meetings with him, about the technical and scientific conversations and about his human and engineering qualities. As a person, he was outstanding, active and energetic, with exceptional designing boldness. He was able, through the prism of the present day, to see the prospects for the development of cosmonautics, its tomorrow and the day after tomorrow. And not simply see, but approach, as well. With his own labor and his own indefatigability. With his own dream.

Several hours before the operation which turned out to be fatal for Sergey Pavlovich, I had the chance to talk with him for the last time. This was late in the evening on 13 January 1966.

I had barely come in the door when my wife handed me the receiver.

"Korolev is asking for you."

In his room on that evening was Nina Ivanovna, his wife. Apparently, they had been talking about the coming morning of the operation.

As soon as I took the receiver and heard his voice, I understood immediately: Korolev's frame of mind had not improved. "What can I say, how can I distract him?"—an idea struck me like a lightning bolt.

"It looks as if you are stuck in the mud there, Sergey," I began rapidly. "Everything has come to a standstill because there is so much that needs to be decided together with you."

"What has happened?" he perked up."

"How could anything happen?" I continued on. "There are a lot of vague items for the State Commission. They are waiting on the flights of Solovyeva and Ponomareva, other crews are being prepared, Babakin has questions about the Luna-9, more precise specifications are needed on equipment... Without giving him a chance to answer, I complained about the difficulties connected with his absence and about the fact that I could not get the entire commission together and could not draw up the documentation because of him.

"You had better get a move on, old boy. These things cannot wait," I said, finishing my long monologue.

Sergey Pavlovich came alive, began to expound his own views and convinced me that it was impossible to postpone the women's flights for any long period of time and that we were training them not for the sake of prestige, but for a specific operation and for science. Feeling that I was tiring him with this conversation, I began to say good-bye.

"O.K., we will talk about the rest later, after you get out. We will be waiting for you, Sergey!"

On 14 January there was a meeting of the ministry's staff. A note was passed to me. I read it and did not believe my own eyes: it informed me that Korolev had passed away.

[5 Apr 88, p 4]

Three In Orbit

[Text] After the six Vostok launches, the matter of the flight of a crew arose. "We will not solve all the problems using single-seater ships," said Korolev. "People with different areas of specialization should be working in orbit because only then will it be possible to advance into space on a broad front. It is necessary to learn to go out into open space and work outside the ship. It may be sooner or later, but this is an absolute requirement."

Two multi-seater ships were being prepared for launching. It was proposed that a crew of three be sent in the first: a commander, an scientific associate-engineer and a doctor; in the second—two pilots, one of which should go out into open space.

There were already difficulties in the fact that the ship's weight is limited by the power capabilities of the launch vehicle. For the base (the first two stages), use was made of that same "semerka" (R-7), while the third stage (the "Ye" unit) had to be replaced with a more powerful one (the "I" unit), which made it possible to increase the spaceship's mass from the normal 4.9 - 5.3 metric tons up to 7.0 metric tons.

We needed the additional weight in order to back up the braking engine system with a reserve solid-propellant engine so as to ensure a soft landing and to accommodate a crew. To supplement the parachute system, a solid-propellant engine was installed in the descent capsule, which is turned on just prior to the landing itself.

The interior of the ship was also subjected to a thorough re-arrangement. There were three non-ejecting chairs with a specially developed shock-absorption system and supports, the attitude-control system had been supplemented by ion sensors and more up-dated instruments had been installed. A serious novelty was that, at the suggestion of G.I. Severin, Korolev decided against the use of pressure suits. The three persons in the first Voskhod were supposed to fly in exercise suits.

It was not easy to solve the question of the crew's make-up. Preparing for flight was a group composed of B. Volynov, V. Komarov, V. Lazerev, K. Feoktistov, G. Katys, B. Yegorov and A. Sorokin. Two pilots, three doctors and two scientific associates. Incidentally, Katys, a professor and doctor of technical sciences, was ardently supported by academicians M.V. Keldysh, A.Yu. Ishlinskiy and V.A. Trapeznikov. Korolev selected Feoktistov, an associate of his own OKB.

Sergey Pavlovich himself earnestly dreamed of flying into space. He personally wanted to try out the equipment developed by them, to experience weightlessness, to live through that unusual condition and to see those unusual colors which the cosmonauts had told about. He wanted to find out what was behind the words "the ship is responsive," "the load factors are tolerable," "it is possible to work"...

He envied Feoktistov, who was 20 years younger than him, but he also understood that nobody could solve the posed problem better than Konstantin Petrovich.

I had known Konstantin Petrovich Feoktistov for a long time, having become acquainted with him in the scientific research institute, where I supervised the scientific section. He had come to us from the MVTU [Moscow Higher Technical School] imeni N.E. Bauman, and had done his diploma work under M.K. Tikhonravov. Energetic and thoughtful, he performed assigned tasks quickly and efficiently. And this with a steady and calm disposition. I was more than pleased with his master's thesis, which was associated with questions of the flight dynamics of the "semerka." He himself was dying to get on the Voskhod and had sent an application addressed to

Korolev long before the start of training, justifying his request by the fact that this matter was as extremely important to him as it was to the spaceship designer. Korolev liked this....

V. Komarov, K. Feoktistov and B. Yegorov blasted off on 12 October 1964.

Man Overboard

In maritime practice, such a phrase has an alarming sound, like an SOS signal. We, the members of the State Commission, were also in a state of anxious expectation regarding the launching, the experiment and the cosmonauts' return on those March days in 1965.

The unusualness of what had been planned required a serious "restructuring" of the ship and its supplementing with special devices and systems and the most careful checks of the Voskhod-2's entire complex. The main change was the appearance of an airlock which would make it possible for a cosmonaut to go out into open space and subsequently re-enter the ship.

Two crews were prepared for the flight: the main crew, made up of P. Belyayev and A. Leonov, and the back-up crew, made up of V. Gorbatko and Ye. Khrunov. They arrived at Baykonur on the 9th of March. The day turned out to be warm and sunny, the smell of spring was in the air and everybody's mood matched that of nature. However, the closer it got to the appointed hour, the more the tension increased.

On 17 March, around midnight, I called Korolev. He was not asleep.

"I visited the boys just a little while ago," I said after a pause. "They are collected, cheerful and ready to work."

"Do you have any doubts?" I asked him.

"I do," he said laughingly. "And you, Mr. Chairman, have you no doubts?"

"That is my job," I replied jokingly. "To cast doubts on everything that you think up... But, to be serious, I think it will be a complete success."

"Leonov is collecting colored pencils to take with him, he wants to make a record in color. He is a splendid fellow. Belyayev is a mature person, very experienced, he will not let us down."

"Pavel Ivanovich has also impressed me with his reserved manner and analytical ability," I concurred.

"I did not conceal from them the complexity of what they are facing," Korolev continued. "I cautioned them that the main thing is accuracy. Take all the circumstances into consideration and make sensible decisions. It is impossible to foresee everything on the ground..."

He sighed and shifted the conversation to a different theme: "And why are you not sleeping?"

"I am thinking about you, Sergey. You have placed too heavy a burden on yourself: the people, the machines, open space, the Moon..."

"I do not need any sympathy, you know I do not like that," he said abruptly."

"Then go to sleep and we will continue the conversation tomorrow in the Commission," I finished. "Good night!"

The chief designer did not have a peaceful night.

The weather on 18 March changed drastically, it had gotten colder. The rocket and the launch pad were dusted with snow. Early in the morning, as always, the State Commission's "pre-fueling" meeting, the reports on the results of the pre-launch check, permission to fuel...

The crew arrived at the launch site. Korolev looked tired, but tried to act cheerful, smiled and hurried the cosmonauts along. Sergey Pavlovich leaned over to Leonov before he got into the elevator and repeated: "You are not to do anything complicated out there, just go out and come back in. May you have a fair solar wind!"

The rocket left the launch site at 1000 hours Moscow time. At 1135, Aleksey Leonov went out into open space. Pavel Belyayev supervised the excursion, was in communication with Leonov and informed the state commission via the ground measuring stations.

The day of the flight went by quickly. Ahead was the landing. In a separate room, from where radio contact was maintained with the crew, the four of us gathered: S.P. Korolev, M.V. Keldysh, Yu. A. Gagarin and myself. Gagarin was at the microphone. In the adjoining hall, where there was a loudspeaker, were the State Commission members, the chief designers and the cosmodrome's management team. They were expecting a routine session. The tension had decreased somewhat, Leonov had been back in his work place for some time now and the air-tightness had been checked. And then came the voice of Almaz-1 [Diamond-1] (Belyayev's callsign): "The TDU did not work automatically [negative automatic retrofire]."

He was talking about the braking engine system [the retro rocket]. The automatic system, which aligned the ship prior to deceleration, had not worked and, therefore, the command for retrofire had not worked either.

I cannot find words to describe our frame of mind. Everyone understood what TDU meant. The possible consequences, also.

There was very little time for making a decision. Minutes counted! Indeed, the ship would be in the radio contact zone for around 10 minutes.

Gagarin looked at us questioningly: "What should we do?" The discussion took about 3 minutes. No more. But, even during this time, the ship had flown along the orbit almost 1,500 kilometers. Gagarin took the microphone and transmitted the State Commission's decision to the ship: "Implement manual attitude control and landing."

Belyayev coped with this task, although attitude control through a viewport required "turning somersaults" inside the ship. On the next orbital revolution, the Voskhod-2 left orbit and rushed downwards. However, this was already not the planned area in Northern Kazakhstan, but significantly "higher" and "off to the side"—180 km from the city of Perm...

They called us from Moscow: "Is everything under control?" was the question."

We were silent and then calmly reported: "Everything is under control, but there is no contact with the crew right now. As soon as we establish contact, we will let you know immediately..."

Soon the State Commission received confirmation of a safe landing. But how to evacuate the crew? How to get through to the people through the taiga [dense forest], the obstructions and the snow? It was necessary to turn to the first secretary of the Perm Oblast Committee of the CPSU, K.I. Galanshin, with a request for assistance to us.

A Lunar Variant

The launches of the second-generation lunar craft also fell to my lot. The first were the celebrated Luna-1, Luna-2 and Luna-3. Those were triumphant launches, carried out by our cosmonautics back in 1959. The first people in the world to reach the Moon, photograph "the back of its head" and go on further routes. And it was no accident that one of these first "lunniks" was called "Dream."

So many bold and most interesting scientific and technical decisions!

The subsequent "Lunas" differed from their predecessors in the fact that they were launched not directly from the cosmodrome, but rather, from a near-earth orbit, into which the vehicle had been placed, together with the last stage of the launch vehicle. Another difference was the conducting of motion trajectory corrections based on the results of its measurements during the flight process. And, finally, deceleration in the pre-landing leg [of the trajectory] and a soft landing was achieved.

Korolev understood that the OKB he supervised, which had been paying more and more attention to the manned flight programs, the problems of docking in orbit and the development of permanent orbital stations, was working with the utmost tension. Therefore, the chief designer's decision to hand over a number of his own "portions" to other design organizations in the industry was completely justified, wise and also generous. In particular, the research programs for the Moon, Venus and Mars were handed over to G.N. Babakin, a gifted designer, a talented scientist, a modest person and one of rare efficiency.

The Luna-8 was already being put together at a new enterprise and its "transportation" had been assigned to our State Commission. The launch took place in December of 1965. This was the last "operation" in which S.P. Korolev participated...

Time accelerated its pace. The roar of the launches pierced Baykonur's sky. A regularly scheduled meeting of the State Commission took place on 31 January, 1966, on the eve of the launching of Luna-9. The technical supervisor was G.N. Babakin. On 3 February, the ninth Luna successfully completed its trip and made a "soft" landing on the Moon. For more than three days, the Earth received the most interesting information.

The sleepless nights, the tea that had cooled in the cups, the emotional flare-ups at the numerous meetings, the difficult work in the MIK Building, the launches in all kinds of weather... This is how it was, this is how it is.

These specific things occurred all these years and in the subsequent ones, the specific scientific programs were carried out and the most complicated tests were performed. It seemed to us that this was a task for the future.

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